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OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

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JULY, 1864.

CIVIL ENGINEERING.

On the Organization of the Corps Imperial Des Ponts-et-Chaussées, in France. By GEORGE R. BURNEEL, ESQ., C.E., F.G.S.

From the Journal of the Society of Arts, No. 591.

As England is approaching the time when the services of the state are destined to be more or less centralized, it seems to me necessary for those who are charged with the superintendence of the various offices of the government to acquaint themselves with the principles upon which foreign nations have organized the bodies to whom they have entrusted the peculiar duties connected with the various branches of the administration. There is, too, a tendency on the part of some of our statesmen of the present day to praise everything that emanates from the French government, particularly with respect to the administration of public works; and as the Corps Imperial des Ponts-et-Chaussées is the most important body that the Minister of Public Works employs upon them, it seemed to me that it would afford the subject of an evening's discussion that would be fraught with interest to you, were I to relate succinctly that which I know with respect to the organization of that body, and of the education that the members of it are obliged to go through.

The public works of France constitute the object of a separate department of the administration of the country, under the control of a minister, who is responsible to the Emperor for the manner in which

he discharges his duties. These consist of the maintenance and the perfection of the means of internal communication, both by land and water; the providing for the safety and convenience of the traffic with foreign countries, by the docks, river navigation, the lighthouses, and beacons of the coast; the works that are undertaken for the improvement of agriculture, such as draining and irrigation works, &c.; the mining operations (by the way, these operations are conducted under the superintendence of a special body of engineers, called the Ingénieurs des Mines, with respect to the organization of whom I read a paper at the meeting of the Royal Cornwall Polytechnic Society, in the month of September last); the conditions that are to be observed with regard to the exercise of unhealthy and dangerous trades; the working of steam engines; the erection and maintenance of the buildings of the state, beyond those that are comprised within the functions of the other ministers; but in many cases the Ingénieurs des Ponts-et-Chaussées enter into the service of the state under the different branches of the administration, as *en service détaché*. The Minister of Public Works has also to prepare and propose the laws for the regulation and control of private commerce; for the encouragement of arts, so far as they are effected by the processes of manufacture. He has the control of the industrial schools, the fund for the superannuation of government employees, the saving banks, the joint stock companies, the private banks, and the superintendence of the service of weights and measures. He is also charged with ascertaining the changes in foreign legislation on the subjects that are likely to interest French commerce, and it is his duty either to publish them, or send them round to those that may be effected by them; according to the regulations that prevailed some time since, he had the superintendence of the general statistics of France, and of the government stations for breeding horses. In the discharge of these duties he is assisted by the Ingénieurs des Ponts-et-Chaussées, for all that relates to the services that come within their functions: thus there is a Direction of Roads and Bridges, that is charged with the surface of the highways, and the departmental roads, and with the police of the traffic upon them. There is a Direction of Navigation, that is charged with the service of the ports and the canals, with the rivers, both navigable and floatable, understanding by the latter word such as are capable of floating down timber, but are not suited for navigation, either on account of their velocity, or their shallowness, or irregular volume; with the police of these rivers, and with the arrangements for their improvements. There is a Direction of Railroads, divided into two sections, of which the first undertakes the regulation of the lines and their concessions; and the second undertakes the works, and the direction of the working of the railroads, and the collection of the statistics of that means of locomotion. The Minister is assisted by the Ingénieurs des Mines in their department, but they are immediately under the orders of the secrétaire-général of that body; in the other branches of his duties the minister is assisted by a numerous staff of officers that relieve him of the care of the details, and allow him to concentrate his attention

upon the broad principles involved in the policy he himself is disposed to carry into effect. It is probable that in the rapidly changing system that now prevails in France, some portion of the duties that are above enumerated, as, for instance, the superintendence of the horse-breeding establishments, may be withdrawn from the functions of the Minister of Public Works, Agriculture, and Commerce; but the list given of the minister's duties was the correct one some time since, and it contains, at any rate, a correct statement of the functions that the French authorities considered to fall within the limits of that officer's occupation.

The Administration des Ponts-et-Chaussées, it is thus seen, forms one of the most important branches of the service of the Minister of Public Works, and is organized in the most systematic manner, according to the French point of view, to secure the effective discharge of the services entrusted to it. The date of the creation of this body is rather remote, and it is another illustration of the manner in which the *Ancien Régime* had prepared the way for the Revolution. As far back as the time of Henry IV. there existed, in fact, a government body of engineers, under the direction of the Grand Voyer of the Kingdom. Louis XIV. gradually increased the power of these engineers; and in 1722, the Regent instituted the Corps des Ponts-et-Chaussées, under its present name, and with nearly the same functions that it has at the present day, for the purpose of executing the system of public works that France had then determined upon. MM. Trudaine, father and son, were the heads of this organization, and they were succeeded by Perronet, in the direction of the Ecole des Ponts-et-Chaussées at any rate, about the year 1750; at the same time the local governments of Languedoc and Bretagne established their separate bodies of engineers on the same footing as that of Paris for the rest of the kingdom. In 1791 the Constituent Assembly passed a decree, maintaining the organization of the Ponts-et-Chaussées, but they introduced into it the system of management that now prevails, and they only recognised one school for it, viz: that of Paris. There have been some changes, without importance, since that period, as in the years 1804, 1817, 1836, 1839, 1853, 1855; but substantially the organization of the administration remains the same as it had been settled by the Constituent Assembly. The acts that have been referred to only made some alteration in the ministry that they were under, and a little difference in the authority of the sous-secrétaire d'état that was specially charged with the direction of the united bodies of the Ingénieurs des Mines, et des Ponts-et-Chaussées.

The minister, then, under the present system approves the projects of the new works submitted to him in the regular course of his business, and those of the great repairs of the roads, bridges, canals, and harbors; he sees to the regularity of the contracts that are taken; he divides the credits allowed by the legislature; and he prepares the decrees regulating the position of the engineers from the second class, observing in all cases the regular system of promotion, unless there be some very peculiar circumstances connected with the case. The

directeur-général has the superintendence of the correspondence with the préfets of the various departments and the engineers; he presides over the meetings of the conseil-général in the absence of the minister; and he prepares all the details of administration that the minister is required to sign. The conseil-général is composed of the engineers of every degree that may be present at the time in Paris; it is presided over by the minister; in his absence, by the directeur-général, or by an inspecteur noninated for the purpose by the minister. It has to pronounce upon the projects and plans of works, and all the questions relating to construction that may arise; upon the questions of accounts, and upon those that concern the legal rights of the state, arising out of the property that it has in the works executed; and, finally, it decides the questions that are connected with the duties of the engineers, that would have to be brought before the council of state or the minister; for in France no person in the employ of the government can be prosecuted for the acts that he may commit in the course of the discharge of his duty, however gross they may be, without the permission of the conseil d'état before whom the actions that may arise must be tried.

The whole of France is divided into eighteen districts, each of which is under the inspection of an engineer, who receives the title of inspecteur-général de 2nde classe; the inspecteurs-généraux de 1re classe being honorary members, and without any definite functions. The inspecteurs are obliged to visit their districts every year, for the space of three months, and they render an account to the conseil-général of the state in which they have found everything in the course of their visit, either with regard to the composition of the staff, the manner in which the accounts are kept, or the conditions they may observe to prevail in the works, such as the roads, bridges, rivers, canals, harbors, railways, factories, ferries, drainage operations, &c. This report must be prepared on paper that allows the engineers in charge of the various parts of the public works to append their remarks to it; or rather the latter have to make a report that is transmitted to the conseil approved and commented upon by the inspecteur; the reports of the latter class of officers, however, that relate to the staff of engineers, are sent directly to the minister, on account of the confidential character of the communications. The service of the departments is divided between the ingénieur-en-chef de 1re classe and the ingénieurs-en-chef de 2nde classe; the ingénieurs-ordinaire de 1re, 2nde, et de 3me classe; and the conducteurs faisant fonctions d'ingénieur-ordinaire, or of the various brigades of the officers of that rank. The ingéniéur de 1re classe is charged with the preparation of the projects for the improvement of his district; the demand for, and the opening of credits; the execution of works either by competition or by régie, which means that the state employs the workmen and engages the tradesmen to furnish materials on its own account; the number of people employed in the offices; the payment of the accounts; and the delivery of the certificates and orders upon the treasury; the direction of the law proceedings; and the movement of the *employees* of the office. The ingénieur-ordinaire presents to the ingénieur-

en-chef the accounts of the measurement of the works executed, and the various conditions of the reception, and the state of those works; he is also charged with the examination of the projects that it may be considered advisable to undertake, which are then submitted to the ingénieur-en-chef, and by him are transmitted to the ingénieur-inspecteur, to be by him co-ordinated with the general projects for the whole kingdom. The ingénieurs-ordinaires are likewise charged with the duty of following the inquiries before the local authorities, into the propriety of establishing certain trades in the localities, that may give rise to question *de commodo et incommodo*, as the French style the questions that are connected with the establishment of unhealthy trades, and the regulation of the lines of buildings on the public roads; the police of the roadways is also within the jurisdiction of the ingénieurs-ordinaires, who are, however, obliged to conform to the orders they may receive from the higher authorities in these matters. It is the duty of the ingénieurs-ordinaires to see that the various contractors execute their engagements with the state in the strictest manner, and they must personally superintend the measurement of the various accounts they certify; they are assisted in the performance of their various duties by the conducteurs, who may, on some occasions, be promoted to the fulfilment of the office of ingénieur-ordinaire; but the rule of the promotion in the Corps des Ponts-et-Chaussées is very much opposed, as we shall see hereafter, to the irregularity of this movement of the last-mentioned body of men; they only are allowed to perform the functions of engineer, whilst they remain conducteurs to the end of their lives.

The Ingénieurs des Ponts-et-Chaussées are admitted into that body in the following manner, that is never departed from, let the candidate for distinction display ever so much knowledge that would become useful in the profession of a civil engineer. The candidate for admission must first of all prove himself capable of going through the examination of the Ecole Polytechnique, and if he support that ordeal, he must study in that school for the space of three years, passing through the examinations that the pupils of the Ecole are subject to every year. He then, after going through another examination, proceeds to the special school of the Ponts-et-Chaussées, where he follows a course of education that is considered to be such as to qualify him to practise as a civil engineer. He has to go through various repetitions and preliminary examinations, that in their variety of subjects, and the profundity of the scientific information that they require, would sorely puzzle the English engineers in the majority of cases; and finally, at the end of three years, the candidate is allowed to pass the final reception, and to be classed as an aspirant-ingénieur, or an ingénieur de 3me classe. The pupils who go through the last examinations with particular distinction are sent abroad to study the peculiarities of foreign practice; and when they return their notes are published, for the most part, in the "Annales des Pont-et-Chaussées." They are then sent with their colleagues to the various places that may be in want of an engineer; but their special talent is hardly considered in the

choice of their pursuit, either in their first nomination or in their subsequent promotion, which follows the regular steps, and leaves little room for the display of original talent of any kind. The consequence of this organization of the school is that the young men leave it with a vast amount of undigested knowledge that would enable them to pass the examinations in the various branches of their profession ; but they rarely possess any practical knowledge whatever. "They are," as M. Etex said in his lectures "On the Fine Arts applied to Industry," "capable of anything and fit for nothing;" and the fact that their promotion in after life depends upon the mere principle of their seniority, tends very much to perpetuate the sort of feeling which the pupils of the Ecole des Ponts-et-Chaussées have when they leave that institution. This may be said to be a perfect self-satisfaction with themselves, such as always accompanies the profession of theoretical as contrasted with practical knowledge, and a contempt for all who may not be so well acquainted with the class of information that they have been enabled to obtain ; and there is this peculiar disadvantage attending the kind of preparation for the future exercise of their profession that the young men who leave the Ecole des Ponts-et-Chaussées are exposed to, that they are obliged to rely greatly upon the conducteurs of that body for all that may relate to the practical details of the pursuit.

When the Ecole des Ponts-et-Chaussées was first instituted, in 1747, by M. Trudaine, on its footing, and Perronet was appointed director of it, the class of education was more general and more decidedly practical than it is now ; and the consequence of this was that the productions of the first engineers of the Ponts-et-Chaussées were characterized by much greater taste than those of their successors. It happens in France, and has been observed to take place in England, that the new inventions and the new processes that are introduced into the building trade are all of them of a nature to require the knowledge by those who employ them, of the powers of resistance of materials ; and as architects are seldom disposed to study the scientific part of their profession (which would be required in the case of these new processes), it follows that the engineers are always consulted when they are to be employed. The inconvenience of the course followed in the education of young engineers is beginning to be felt in the supreme ugliness that they give to the monuments they are called upon to design ; and there are serious questions whether it would not be worth while to change the system of education, in order to introduce some principles of taste, such as had marked the productions of the earlier engineers. Perhaps this might be effected, if the knowledge of free-hand drawing from the figure were made an essential part of the course of examination, and proof were required of the attendance of the pupils at course of lectures in architecture and archæology ; but this is at any rate certain, that the engineers of the Ponts-et-Chaussées invariably spoil the opportunities that are afforded them to erect civil buildings, and that the various bridges that they are employed to execute are very deficient in the monumental grandeur that characterized the productions of Huppeau, Pitrou, Perronet, Chezy, Lamblardie, De Prony, &c. This is, after all,

a question that interests the lovers of æsthetics, and may for the time be set aside, the more especially as the tendency of everything that is happening in England and America is towards the same state of indifference to the effect of the great work entrusted to the engineers; provided the works satisfy the conditions of stability that are required in them, the public seems contented to set aside the consideration of their beauty in France as well as in England; and the accusation against the engineers of the Ponts-et-Chaussées, that their productions are deficient in taste, must, at any rate, be shared by their colleagues in other countries that pretend to as high a state of civilization as France.

The engineers, however, after leaving the school, are sent, as was said, to the place that may be vacant, whatever the nature of the occupation may be there; they are then promoted, as was before said, in the order of their seniority, unless there be some very strong grounds for making an exception for or against them. They are expected to observe towards one another the kind of respect that is always observed in a military organization, and to exact the same respect from their subordinates; so that the conducteurs are always treated with the same kind of distance with which an officer would treat a common soldier. There are three kinds of service—the service ordinaire, the service extraordinaire, and the service détaché. Of these, the service ordinaire comprehends three classes—the service général, that includes all the ordinary kinds of works that fall within the duties of the Ponts-et-Chaussées; the service spécial, that embraces the direction of the works that are separated from the state budget, and are paid for by the departments; and the service des conseils généraux, that comprehends the general administration of the body, and the service of the Ecole des Ponts-et-Chaussées, and of the depot of maps and plans. The service extraordinaire includes the superintendence of various works that are paid for by the state, but do not enter into the ordinary occupations of the engineers; such as the service of the lighthouses, the works against inundations, the reclamation of the Sologne, &c.; whilst the service détaché comprehends the works that are executed for the departments of the state that are not included in the budget of the Minister of Public Works; such as the harbors of Brest, Cherbourg, L'Orient, Rochefort, Toulon, the colonies, the expeditions to foreign countries, Algeria, and the municipal service of Paris, Lyons, and other large towns. The salaries paid to the various grades are—for the inspecteurs-généraux de 1re classe, 12,000 francs per annum; of the 2nde classe, 10,000 francs per annum; ingénieurs-en-chef de 1re classe, 6000 or 5000 francs per annum; of the 2nde classe, 4500 francs per annum; ingenieurs-ordinaires de 1re classe, 3000 francs per annum; ditto, of 2nde classe 2500 francs per annum; ditto, of 3me classe, 1800 francs per annum; the pupils of the Ecole des Ponts-et-Chaussées receive 1200 francs per annum, and when they are employed on mission they receive 1800 francs. The engineers are, besides their salary, entitled to charge their office expenses, which are fixed by the minister; but, with this exception, and the exception of

some works that the engineers are allowed to undertake for the account of the communes, they are strictly limited to the appointments allowed them by the government. I can myself vouch for the fact that the engineers, notwithstanding the moderate amounts of these salaries, are almost universally pure and honest, in the noblest degree; they scorn to receive bribes; and the tone of morals that prevails amongst them in all that relates to pecuniary affairs might serve as a useful lesson to ourselves. This is, perhaps, aided by the conviction that they cannot be discharged from their functions, or debarred from their promotion, unless under very peculiar circumstances of misconduct. They have also a retiring pension in their old age, and their position in society is about the highest in the French administration, from the esteem and respect that always attaches itself to the possession of the class of knowledge that they must attain. The influence of the money-making tendency of the age may be detected, perhaps in some cases, but generally speaking, every one that has had occasion to know the Ingénieurs des Ponts-et-Chaussées must bear the highest testimony to their profound sense of honor and delicacy of feeling.

One great cause of the efficiency of the service of the engineers is, however, to be found in the body of conducteurs or clerks of the works whom they employ, and who are engaged upon the field operations, the superintendence of the workmen, the measurement of the works done, and the preparation of the drawings that are sent out from the engineer's office. The nomination of these men is rather singular, and takes place somewhat after this fashion:—The engineer receives a young man into his office, without salary at first, and he brings him up to the details of his business; at a certain time the men present themselves for examination as conducteurs, and they become embrigadés if they can pass that ordeal, which is made to embrace the whole range of sciences that are concerned with the practice of civil engineering, such as geometry, the theory of numbers, logarithms, the drawing of plans, levelling, taking out quantities, measuring work, the superintendence of it, and generally all that would be required for carrying works into effect. They become then conducteurs embrigadés de 4me classe, and they pass through the ranks of the third, second, and first classes, in the order of their seniority generally; but they may mount in grade more rapidly, in proportion to their merit or their patronage. By the law of 30th October, 1850, it was provided that the sixth of the places of the engineers should be reserved to the conducteurs that had been in the service for the space of ten years, and who could then pass the examination that the engineers were subjected to; but this provision has hitherto been perfectly nugatory, for since its promulgation there has not been a single promotion from the body of conducteurs. The utmost they can aspire to is to be allowed to perform the functions of a civil engineer, whilst they retain their old rank. They would be regarded as intruders if they forced themselves into the society of engineers, as the equals of the latter, by taking advantage of the letter of the law. The consequence of this state of affairs is, that the pupils of the Ecole Polytechnique have practically

the monopoly of the government employment in the place of the Ponts-et-Chaussées, for the conducteurs do not aspire to that title, let them be ever so learned or ever so capable; and thus the French revolution has perpetuated the inequality of conditions, by giving the monopoly of the profession to those that can afford to pay for the education that is given in the schools—a strange commentary upon the doctrines of equality that the revolution was intended to inaugurate.

There is a very great inconvenience arising from the strictly theoretical style of education that the young engineers are called upon to go through, that consists in the desire the bulk of them possess to distinguish themselves by the construction of works of a monumental character, without any regard to the conditions of economy that would be applicable in the majority of cases. The principle of the French law is that the architect is responsible for the solidity of the building that he may put up, against any defects of construction or erection, for the period of thirty years; and though the Ingénieurs des Ponts-et-Chaussées do not come under the strict application of the law, owing to their not working for a commission, yet the tendency of the law is to produce a great degree of strength, and a solidity of execution, that may be traced in all the works they execute. The administration requires, in addition, that no work should fail; the engineer that risks much is looked upon as a dangerous and troublesome man. There is every inducement, therefore, for the engineer to erect "monuments," and the character of the works of the Ponts-et-Chaussées is marked with the grandeur and the magnificence that was formerly the distinguishing mark of the Roman engineers; but the cheap and expeditious systems that prevail in England and America are regarded with dislike and contempt. One other objection may be made to the French system, in the total absence of original thought that it developes. The best subjects, as they call them, are obliged every year to travel in foreign countries, and the works that are done in France are generally the productions of civil engineers and the somewhat despised race of architects. The Ingénieurs des Ponts-et-Chaussées do not attempt to produce any new style—they only seek to construct "monuments" that shall last forever regardless of cost. The tendency of the body of the Ponts-et-Chaussées to this style of work is also, to a great extent, assisted by the publication of the journal of the body, that appears about six times a year, under the name of the "*Annales des Ponts-et-Chaussées*," and is characterized by the excessive love of theory, and the abuse (if I may say so much) of mathematical and other scientific knowledge, that may be reproached to the whole of the present school of French engineers. The members of that profession who communicate the information that is inserted in this journal, are, in fact, obliged to treat every subject which they undertake in the most abstract manner, as though they constructed or designed works for the sake of resolving problems of science, instead of endeavoring to answer the questions that might arise, with the purpose of constructing the works economically; they cultivate science as the end of their labors—they do not look upon it as the means to the end. The same observation may

be extended to the bulk of French scientific works, whether they be brought out by the Ingénieurs des Ponts-et-Chaussées or by the ingénieurs civils, for the latter are obliged to follow the example set by their rivals, and to employ a great amount of science on the simplest operations of their pursuit. Yet there is a great advantage in thus substituting the indications of theory for the rule-of-thumb processes that are still too prevalent here; and the contrast that is presented between the French engineering journals and the English productions of the same kind is but little to the credit of our scientific and practical men.

(To be Continued.)

To Deaden Sound.

From the London Builder, No. 1107.

In answer to your correspondent as to the best means of deadening sound, when altering an old house in North Lancashire, about four years ago, I met with the best deadened floor I ever saw. Long moss had been gathered in the adjoining woods, dried, and mixed with dry lime rubbish, and filled in between the joists. I adopted the same method in the new portion of the house with equal success. The moss has the advantage of being exceedingly light. The lime rubbish should be well screened and mixed with the moss, great care being taken to leave no part unfilled. The neglect of this is, in my experience, a very common cause of failure. R.

Effect of Curvature in Retarding the Passage of Trains.

From the London Mechanics' Magazine, April, 1864.

American engineers appeared to underrate the effect which curvature produced in retarding the passage of trains; while English authorities differed materially in their views upon the subject. As the author believed practical data were wanting, he had appended to the paper a list containing the length of every curve and straight line upon the Tabon incline, specifying the gradient in each case. Further, he had made a few imperfect experiments, to ascertain the resistances due to sharp curves in combination with steep gradients, the results of which might be taken at all events as approximations to the truth. They were tried with a dynamometer, similar to a spring balance in its form and arrangement, but of only sufficient power to allow of one loaded wagon, of a gross weight of 10 tons, being employed. According to these experiments, the particulars of which were given in detail, upon a straight line with a gradient of 1 in 50, the resistances were 55 lbs. per ton of train, corresponding with those deduced by the ordinary mode of calculation; while upon the same gradient combined with curves of 600 feet radius, the resistances were augmented to 70 lbs. per ton of train. By the formula of Latrobe, the resistance due to this curvature was only 5·09 lbs. per ton of train. Professor Rankine's gave 12·3 lbs. per ton of load. These experiments appeared to show that, upon a curve of 1000 feet radius, the resistance was double that upon

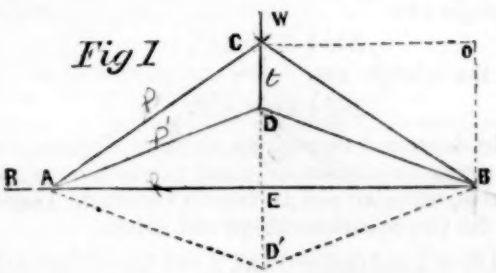
a straight line; and upon a curve of 600 feet radius, it was equal to the gravity on an inclined plane of 1 in 150. Approximately, the resistance due to the curvature might be found, either by dividing the number of lbs. in a ton by 0·224 of the radius of the curve, or by multiplying the deflection angle of the curve by 1·75, to give the resistance in lbs. per ton of train. It should be stated, that the gauge of the line was 5 ft. 6 ins. and that the proper super-elevation had been given to the outer rail on curves.

For the Journal of the Franklin Institute.

Solutions of a Problem of the Rafters. By S. W. Robinson, C. E., Detroit, Mich.

I offer the following for publication for the interest manifested in consequence of the numerous solutions by the "triangle of forces," by "moments," by "virtual velocities," or by "the shearing stress." I have met with scarcely another problem whose solution by either of these principles can be made with so nearly equal facility.

Fig 1



Let AC, CB represent the rafters AD, DB or AD′, D′B sub-rafters, or rods joined at their intersection D or D′ with the intersection at C by a tie or strut DC or D′C. And let W be a force acting at C tending to depress C, causing a thrust at A and B, tending to straighten AD, DB or AD′, D′B causing a stress upon DC, or D′C.

Required the amount of stress t upon DC, *or* D′C.

When the force W is acting at C, and the combination is in equilibrium, there results a force t acting at C. There is a horizontal thrust at A and B caused by the force at C, which is resisted by an equal and opposite force in AD, and DB. Call this force R.

Now as the forces in any triangle of forces are proportional to the sides of the triangle respectively, we will have from the triangle

AEC, AE : EC = R : $(W \pm t)$ whence $R = (W \pm t)\frac{AE}{EC}$.

Also from the triangle AED, AE : ED = R : t, whence

$$R = \frac{AE}{ED}t \text{ or } \frac{AE}{ED'}t = (W \pm t)\frac{AE}{EC}, = W\frac{AE}{EC} \pm t\frac{AE}{EC}$$

by equating; from which

$$t\left(\frac{1}{\text{ED or ED}'} \mp \frac{1}{\text{EC}}\right) = \frac{\text{W}}{\text{EC}};$$

$$\text{whence } \frac{t}{\text{EC}}\left(\text{EC} \mp \text{ED or ED}'\right) = \frac{t}{\text{EC}}\left(\text{CD, or CD}'\right) = \frac{\text{W}}{\text{EC}}\left(\text{ED or ED}'\right)$$

$$\therefore\ t = \text{W}\frac{\text{ED}}{\text{CD}} \text{ or } \text{W}\frac{\text{ED}'}{\text{CD}'}.$$

To make the solution by moments, draw CO and OB parallel to EB and EC.

Then $\quad \text{R} \cdot (\text{BO} = \text{EC}) = (\text{W} \pm t)(\text{CO} = \text{EB})$

and $\quad t \cdot \text{EB} = \text{R} \cdot (\text{ED or ED}')$

or $\quad t \cdot \text{EB} = (\text{W} + t)\frac{\text{EB} \cdot \text{ED}}{\text{EC}}$

from which $\quad t = \text{W}\frac{\text{ED}}{\text{CD}}$.

To make the solution by the principle of virtual velocities, we have from the triangle AEC

$$\overline{\text{AE}}^2 + \overline{\text{EC}}^2 = \overline{\text{AC}}^2,$$

And from the triangle AED

$$\overline{\text{AE}}^2 + \overline{\text{ED}}^2 = \overline{\text{AD}}^2.$$

Now if C be depressed through an element of space, A will move horizontally through an element of space in which case AE, EC, and ED become variable, while AC and AD remain constant. Therefore we may differentiate the two equations above and obtain

$$2\,\text{AE}d(\text{AE}) + 2\,\text{EC}d(\text{EC}) = 0 \text{ and } 2\,\text{AE}d(\text{AE}) + 2\,\text{ED}d(\text{ED}) = 0.$$

Eliminating $\text{AE}d(\text{AE})$ gives

$$\frac{d(\text{EC})}{d(\text{ED})} = \frac{\text{ED}}{\text{EC}}.$$

The element of space $d(\text{EC})$ may be regarded as that through which C passes; and $d(\text{ED})$ the element through which D passes. Hence each force multiplied into its displacement gives

$$(\text{W} + t) \cdot d(\text{EC}) = t \cdot d(\text{ED}),$$

or $\quad (\text{W} + t)\frac{d(\text{EC})}{d(\text{ED})} = t.$

Substituting for the ratio of the infinitessimals its value above, then

$$(\text{W} + t)\frac{\text{ED}}{\text{EC}} = t,$$

from which $\quad t = \text{W}\frac{\text{ED}}{\text{CD}}$.

To make the solution by means of the principle of shearing stress. The shearing stress of a beam with reference to any section, is the

amount of force which tends to move one part of the beam over the other, every particle of the beam moving in a direction parallel to this section.

Therefore if the force in AC be P and that in AD be P′, the vertical shearing stress of AC will be

P sin EAC; and as this is the total vertical resistance of AC; it must be equal to the total vertical force acting upon it;

Hence $$P \sin EAC = W + t.$$

Similarly the vertical shearing of AD is

$$P' \sin EAD = t.$$

Taking the horizontal shearing we have

$$P \cos EAC = R, \text{ and } P' \cos EAD = R.$$

Reducing we get

$$R \operatorname{tang} EAC = W + t, \text{ and } R \operatorname{tang} EAD = t,$$

or $$t \frac{\operatorname{tang} EAC}{\operatorname{tang} EAD} = W + t.$$

But $\operatorname{tang} EAC = \frac{EC}{EA}$, and $\operatorname{tang} EAD = \frac{ED}{EA}$.

$$\therefore \quad t \frac{EC}{ED} = W + t, \text{ or } t = W \frac{ED}{CD}.$$

Other solutions might be made by some of these four principles. Thus, by the triangle of forces, taking AE to represent R, and EC to represent $(W+t)$, and ED to represent t, we would obtain

$$R \operatorname{tang} EAC = (W+t), \text{ and } R \operatorname{tang} EAD = t,$$

which is reduced similarly as the last.

To make a second solution by the principle of "virtual velocities," let C move through an element of space to C′ Fig. 2. At the same time B will move to B′. Draw through B′, B′H parallel and equal to BC, then HC = B′B and the triangle HCC′ is similar to CEB, which gives BE : EC = C′C : CH = C′C : BB′

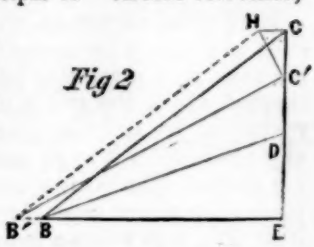


Fig 2

whence $\frac{BB'}{CC'} = \frac{EC}{BE}$.

By the principle of "virtual velocities,"

$$R \,.\, BB' = (W+t) \,.\, CC',$$

or $$R \frac{EC}{BE} = W + t.$$

Similarly we would get from BED

$$R \frac{ED}{BE} = t,$$

which may be reduced as similar expressions above.

If in the result for t we make ED=0, t=0. If we make CD=0, $t=\infty$.

If we multiply through by CD and make CD $=\infty$, then ED$=\infty$. Similar conclusions would be drawn from the figure.

If AE and EB, Fig. 1, be taken unequal, we get a similar expression for t.

MECHANICS, PHYSICS, AND CHEMISTRY.

The Macrograph. By Wm. B. Morgan, M. A., Prof. of Math. and Ast. in Earlham College, Richmond, Ind.

To the Editor of the Journal of the Franklin Institute.

The following article is a copy of a thesis which was prepared by Mr. Morgan previous to his taking the degree of Civil Engineer at the University of Michigan, in June, 1863.

I offer it to you for publication on account of its originality, and the hope that it will induce further investigation. It may result in reducing the principles involved to some useful application.

D. V. Wood, Prof. Civ. Eng.

This instrument, being as yet without a name, the author of the following article has concluded to call it *The Macrograph*, from its property of describing long curves. (Gr. μακρος, *long*, and γραφω, *to write.*)

The Macrograph is the invention of Oliver Butler, Attorney at Law, Richmond, Indiana.

I. The instrument is represented by Fig. 1, Plate I. It has two cog-wheels, A and B—the latter moving the former—the *number* of teeth in the two being different.

Each wheel carries an arm, M M′, which may be shortened or lengthened at pleasure by means of adjusting screws. At the extremity of the arm, M, is a rotating pivot, P, with a binding screw and a mortise through which the rod R passes. The rod R is attached to the extremity of M′, and also passes through pivot P′, which may be placed any where upon it at pleasure, and fixed there by means of the binding screw. The pivot P′ rotates in the slider S. The latter may be placed any where upon the rod R. This latter rod has holes in it at H H′, &c., into which a pencil may be inserted.

Upon turning the crank of wheel B, while the instrument is in the position indicated, it will describe a curve or rather a series of curves, of which Fig. 2 is a specimen. By placing the pencil in other parts of the same, four figures may be made which differ so much from this specimen, that one would hardly suppose that they were governed by the same law.

It is evident from the construction of the instrument, that if the wheels contained the same number of cogs in each, with any particular arrangement of the pencil, rods, pivots, &c., the pencil must follow in the same path at successive revolutions of the wheels. This

path *might be* a straight line, a loop, or some other shaped figure. While the number of cogs is unequal, it is evident that the path must vary continually until the same relative position of the cogs is reached which existed at the commencement of the curve.

II. The rod R′ may be removed, and the pivot at L inserted into slide S. The mortises in slide S and pivot P have slits in them equal to the thickness of the pencil through which the latter may work. Since the wheels are unequal in size, it is evident that, in order to manipulate the instrument, the binding screw of either the slider or the pivot must be loosened. By this arrangement we may describe two systems of curves differing somewhat in principle of construction.

Fig. 3 is a sample of the curves described when the binding screw of the slider is loosened.

If the binding screw of the pivot be loosened, we may describe curves of which Fig. 4 is a sample.

III. Lastly, the wheel A may be removed, and a pivot in the lower part of the slider s′ inserted into the slider S. The binding screws of s′ and S being tightened, and that of pivot P loosened, a pencil inserted into any of the holes will describe an arc of a circle. If the slider s′ is loosened and pivot P tightened, the pencil immediately under s′ will describe a straight line; at every other point an oval, with its extremity nearer to s′, more or less sharp, according to its proximity to s′.

Figs. 5 and 6 are examples.

Again s′ may be fastened at any point of rod R′, the pivot P being tightened, and the slider S loosened. Fig. 7 shows three such curves described, with the pencil at three different points.

It is this class of curves that I have partially investigated. The discussion of the curves described by the first two arrangements of the instrument, would probably be more curious than practically useful. The only useful application of the first two combinations which suggests itself to the writer, belongs to the engraver's art. A graver's tool, properly constructed upon the same principle, might produce curves which it would be impossible to counterfeit. By the use of cams, eccentrics, and elliptic wheels, not exhibited in the drawing, the figures may be infinitely more diversified.

It is possible that the *single* curves described by the *third* arrangement may be useful to the engineer. At any rate, it is his province to investigate every manner of curve, and ascertain whether in his extensive department for applied mathematics, each may not find some place for conducing to strength and symmetry.

The problem which I have partially solved may be thus stated:

The end of a straight line is made to follow the circumference of a circle, while the line passes through any fixed point; what is the equation and some of the properties of the curve described by any point of the given line?

Let E, Fig. 8, be the centre of the given circle, A B the given line, and *p* the given point.

Let R = radius of the given circle.
a = length of AB = A′B′.
r = PB = P′B′ = radius vector of curve.
d = PE.
t = angle BPK.

We have,

$$r = a - \text{AP (or A}'\text{P}') = a \pm \text{AF} - \text{PF}, \quad . \quad . \quad (\text{A})$$

But $\text{PF} = d \cos t$,
and from triangle PEA, $d : \text{R} :: \sin \text{A} : \sin t$;

$$\therefore \text{R} \sin \text{A} = d \sin t, \quad . \quad . \quad . \quad (a)$$

Subtract the square of both members of a from R^2, and we find

$$\text{R} \cos \text{A} = \pm \sqrt{\text{R}^2 - d^2 \sin^2 t} = \text{AF or A}'\text{F}, \quad . \quad (b)$$

These in (A) give

$$r = a \pm \sqrt{\text{R}^2 - d^2 \sin^2 t} - d \cos t,$$

which is the polar equation of the curve.

From this equation we see that for every value of t there are two values for r, the difference of which is $2\sqrt{\text{R}^2 - d^2 \sin^2 t} = 2\,\text{R} \cos \text{A}$ (see (b)). Whence it appears, as is also evident from the construction, that the chord BB′ = the chord AA′.

From (a) we have $\sin t = \frac{\text{R} \sin \text{A}}{d}$, from which we see that the superior limit of t is

$$\sin^{-1} \frac{\text{R}}{d}, \quad . \quad . \quad . \quad . \quad (c)$$

$$\text{or,} \qquad \cos^{-1} \sqrt{\frac{d^2 - \text{R}^2}{d^2}}$$

$\therefore$ if $d = \text{R}$ the limit is 90°.

On condition that $d = \text{R}$, or that the point through which the given line passes is situated on the circumference of the given circle, the equation of the curve becomes $r = a$ or $r = a - 2\,\text{R} \cos t$.

With the former the point describes a semicircle, and with the latter a curve meeting the extremities of this semicircle, modified by the length of a.

Fig. 9 shows two such curves. The first differential co-efficient of the latter equation is $\frac{dr}{dt} = 2\,\text{R} \sin t$; $\therefore \frac{dt}{dr} = \frac{1}{2\,\text{R} \sin t}$, which is the value of the subnormal. Hence the value of the subnormal is independent of the radius vector. Then, for the same value of t in a system of such curves described with different radii, if normals be drawn to the curves at the extremity of the radii, as at L, L′, &c., these normals will all meet in a single point C, PC being the subnormal.

For every radius vector drawn from P through the curves, there would be a particular point, C, where the normals would meet. The

locus of these points would not be the straight line PC, but would form a curve.

[If several lines of intrenchments be made, one behind the other, and of the form of these curves, then batteries placed in the same radius vector, as at L, L′, &c., might concentrate their fire at the same point, C, when their line of sight is normal to the curve.]

From the theory of curves we have

$$\text{the subtangent} = \frac{r^2 dt}{dr} = \frac{(a - 2R\cos t)^2}{2R\sin t} \quad . \quad . \quad (D)$$

$$\text{Tangent} = r\sqrt{1 + \frac{r^2 dt^2}{dr^2}} = \frac{a - 2R\cos t}{2R\sin t}\sqrt{4R^2 + a^2 - 4aR\cos t} \quad (E)$$

$$\text{Normal} = \sqrt{r^2 + \frac{dt^2}{dr^2}} = \sqrt{(a - 2R\cos t)^2 + \frac{1}{4R\sin^2 t}} \quad . \quad (F)$$

If in these we suppose $a = 2R$, corresponding to the curve MMP we have

$$\text{Subtangent} = 2R\frac{(1-\cos t)^2}{\sin t}, \text{ for } t = 90° = 2R \quad . \quad . \quad (d)$$

$$\text{Tangent} = R\sqrt{8}\frac{(1-\cos t)^{\frac{3}{2}}}{\sin t}, \text{ for } t = 90° = \sqrt{8}R \quad . \quad . \quad (e)$$

$$\text{Normal} = \sqrt{\frac{1}{4R^2\sin^2 t} + 4R^2(1-\cos t)^2}, \text{ for } t = 90° = \sqrt{\frac{1+16R^4}{4R^2}} \quad (f)$$

and if $t = 0$ we have subtang $= \frac{0}{0}$, tan $= \frac{0}{0}$, normal $= \infty$, which indicates a cusp.

If in (D), (E), and (F), we make $t = 90°$, we shall have

$$\text{subtan} = \frac{a^2}{R^2}, \quad \tan = \frac{a}{2R}\sqrt{\frac{4a^2R^2 + a^4}{4R^2}}, \quad \text{normal} = \sqrt{\frac{1 + 4a^2R^2}{4R^2}}$$

and if $t = 0$,

$$\text{subtan} = \frac{(a-2R)^2}{0} = \infty, \quad \tan = \infty, \quad \text{normal} = \infty.$$

To find the area, use the equation $dA = \frac{1}{2}r^2 dt$, in which substitute the value of $r = a - 2R\cos t$, and integrate, and we readily find

$$A = \tfrac{1}{2}a^2 t - 2aR\sin t + R^2 t + \tfrac{1}{2}R^2\sin 2t + (C = 0).$$

For $t = 90°$ we have

$$A = \tfrac{1}{4}\pi a^2 - 2aR + \tfrac{1}{2}\pi R^2$$

Hence the whole area N N N $= \pi(\frac{1}{2}a^2 + R) - 4aR$.

If $a = 2R$ we find for the area M M P M M $= (3\pi - 8)R^2$.

Radius of Curvature.

In the general expression

$$\rho = \frac{\left[r^2 + \left(\frac{dr}{dt}\right)^2\right]^{\frac{3}{2}}}{r^2 + 2\left(\frac{dr}{dt}\right)^2 - r\frac{d^2 r}{dt^2}},$$

Substitute $r=a-2R\cos t$, $\frac{dr}{dt}=2R\sin t$, $\frac{d^2r}{dt^2}=2R\cos t$ and reduce, and we find

$$\rho=\frac{[a^2-4aR\cos t+4R^2]^{\frac{3}{2}}}{a^2-6aR\cos t+8R^2} \quad . \quad . \quad . \quad (G)$$

If $t=0$, then $\rho=\rho_0=\frac{(a-2R)}{a^2-6aR+8R^2}$ . . . (G')

If $t=90°$ then $\rho=\rho_1=\frac{(a^2+4R^2)^{\frac{3}{2}}}{a^2+8R^2}$ . . . (G'')

In these make $a=2R$ and we find

$$\rho=\frac{2^{\frac{5}{2}}}{3}R(1-\cos t)^{\frac{1}{2}} \quad . \quad . \quad . \quad (H)$$

$$\rho_0=\frac{0}{6} \quad . \quad . \quad . \quad . \quad (H')$$

$$\rho_1=\frac{2^{\frac{5}{2}}}{3}R \quad . \quad . \quad . \quad . \quad (H'')$$

For T, T' we have $TT'=r\cos t=a\cos t-2R\cos^2 t$,

which is a maximum for $\cos t=\frac{a}{4R}$ . . . (I)

For $a=2R$, $\cos t=\frac{1}{2}$ $\therefore$ $t=60°$

Application to the Arch.

Suppose we have an arch constructed with the curvature NNNN, having a pier in the centre. This would make a graceful arch.

Let θ = the angle which the tangent line to the curve makes with NPN, or with the axis of x, and

V = the angle which the tangent line makes with the radius vector at the point of tangency.

Then $\tan V=r\frac{dt}{dr}=\frac{a-2R\cos t}{2R\sin t}$

$$\theta=V-(90-t)=V+t-90°$$

$$\therefore\ \tan\theta=-\cot(V+t)=\frac{\tan V\tan t-1}{\tan V+\tan t}=\frac{a\tan t-4R\sin t}{a-2R(\cos t-\sin t\tan t)}.$$

Substitute $\frac{\sin t}{\cos t}$ for $\tan t$ and reduce, and we have

$$\therefore\ \mathrm{Sec}^3\theta=\left[1+\left(\frac{a\sin t-2R\sin 2t}{a\cos t-2R\cos 2t}\right)^2\right]^{\frac{3}{2}} \quad . \quad . \quad (K)$$

Now if z = depth of loading at any point,

m = depth of loading at the crown, N,

ρ_0 = radius of curvature at the crown,

ρ = radius of curvature at the point corresponding to z, we have (See Professor Wood's Lectures)

$$z=\frac{m\rho_0}{\rho}\sec^3\theta \quad . \quad . \quad . \quad (L)$$

Fig. 5.

Fig. 6.

Fig. 2.

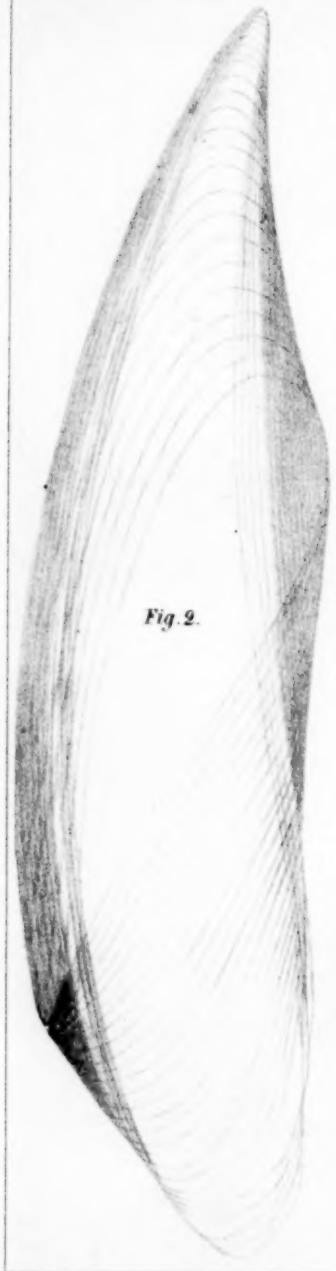


Fig. 9.

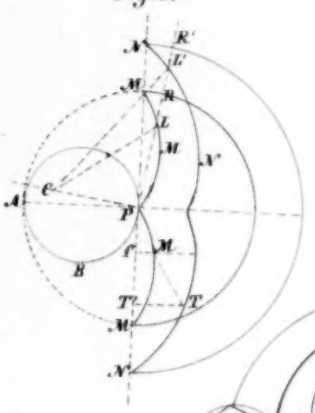


Fig. 1.

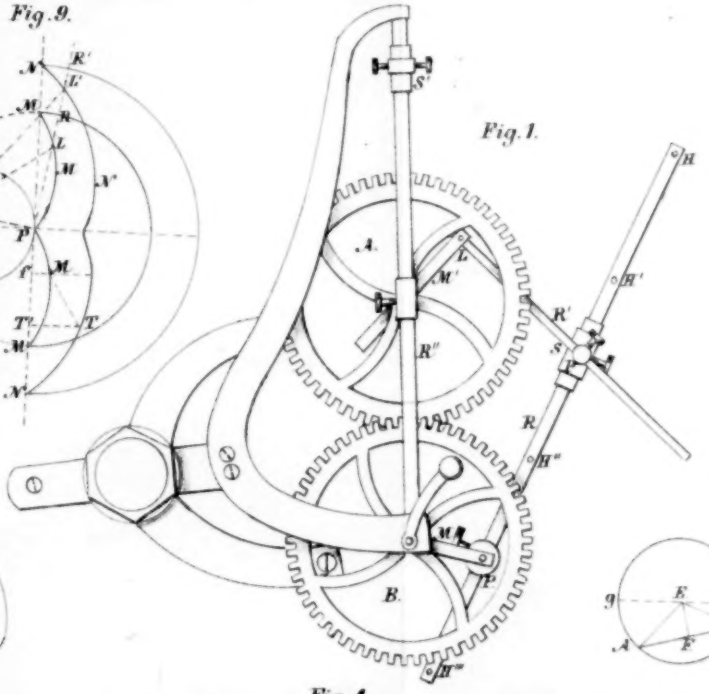


Fig. 3.

Fig. 7.

Fig. 8.

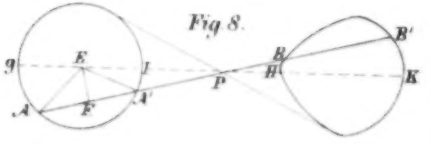
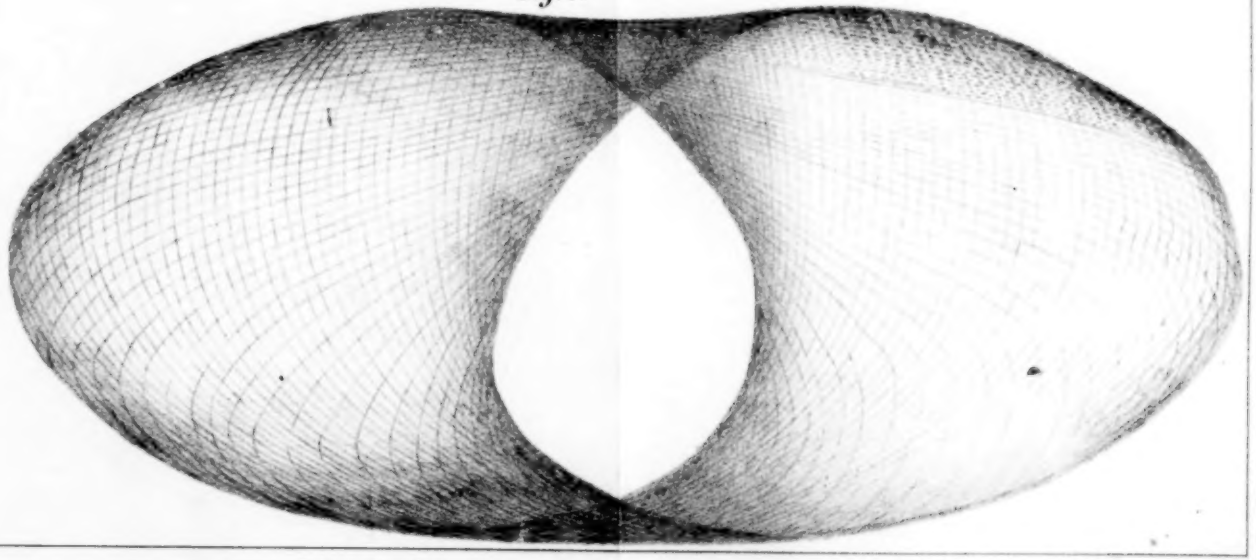


Fig. 4.



Equation (L) is thus deduced—

If the arch is a curve of equilibrium, the resultant of the forces at any point will be in the direction of the tangent.

Let T=the tension or compression at any point,
ΣY=the sum of all the vertical forces from the crown to the point considered,
H=the thrust at the crown,
δ=the weight of a unit of volume.

The other notation is given above.

Resolving the tension horizontally and vertically, we have

$$T\frac{dx}{ds}=\Sigma Y=\int \delta z\, dx.$$

$$T\frac{dx}{ds}=H.$$

Dividing gives

$$\frac{dy}{dx}=\frac{\int \delta z\, dx}{H}=\tan\theta.$$

Differentiating gives $\frac{d^2y}{dx^2}=\frac{\delta z}{H}$.

These in the value of the radius of curvature give

$$\rho=\frac{\left(1+\frac{dy^2}{dx^2}\right)^{\frac{3}{2}}}{\frac{d^2y}{dx^2}}=H\frac{\sec^3\theta}{\delta z}$$

$$\therefore\quad z=\frac{H\sec^3\theta}{\delta\rho}.$$

For $\theta=0$, $z=m$, and $\rho=\rho_\circ$ $\therefore\ m=\frac{H}{\delta\rho_\circ}$ which combined with the former equation gives

$$z=\frac{m\rho_\circ\sec^3\theta}{\rho}$$ as given above.

To find $\rho_\circ$ substitute $\cos t=\frac{a}{4R}$. (See (I)) in (G) and we find

$$\rho_\circ=\frac{16R^3}{16R^2-a^2}. \qquad . \qquad . \qquad (M)$$

Substitute the value of $\sec^3\theta$ from (K), ρ from (G) and $\rho_\circ$, in (L) and we find

$$z=m\frac{16R^3}{16R^2-a^2}\left[\frac{a^2-6aR\cos t+8R^2}{(a^2-4aR\cos t+4R^2)^{\frac{3}{2}}}\right]\times$$
$$\left[1+\left(\frac{a\sin t-2R\sin 2t}{a\cos t-2R\cos 2t}\right)^2\right]^{\frac{3}{2}} \qquad . \qquad (M')$$

If $\cos t = \frac{a}{4R}$ we have $z = m$

$t = 90°$ we have $z = 2m \frac{8R^2 + a^2}{16R^2 - a^2}$ . . (M″)

$t = 0$ we have $z = m \frac{16R^3}{4R + a} \cdot \frac{(4R-a)^{\frac{1}{2}}}{(2R-a)^{\frac{3}{2}}}$. (M‴)

If $a = 2R$, which corresponds to the curve MMP we have

$$z = \tfrac{1}{2} m \frac{1}{\sin \frac{1}{2}t} \left[1 + \left(\frac{\sin t - \sin 2t}{\cos t - \cos 2t} \right)^2 \right]^{\frac{3}{2}} \quad . \quad (N)$$

for $t = 60°$, $z = m$ . . . . (N′)

$t = 90°$, $z = 2m$ . . . . (N″)

$t = 0$, $z = \infty$ . . . . (N‴)

From (N″) we see that the depth of loading at the extremity should be twice that at the crown.

If, then, a portion contained between $t = 60°$ and $t = 90°$ were taken for half the span of an arch, and the other half span constructed similarly, we should have the form of an arch which might, in some cases, be useful, for instance, in covered arches for aqueducts. The upper portion of the load may be horizontal, provided its thickness over the top of the arch is equal to the rise of the arch.

Utilization of Brine. A Practical Application of Dialysis.

From the London Chemical News, No. 225.

Mr. Whitelaw, of Glasgow, has recently described the result of a patent process of his own for utilizing the brine of salted meat. When fresh meat, he said, had been sprinkled with salt for a few days, it was found swimming in brine. Fresh meat contained more than three-fourths of its weight of water, which was retained in it as in a sponge. But flesh had not the power to retain brine to that extent, and in similar circumstances it absorbed only about half as much saturated brine as of water, so that under the action of salt flesh allowed a portion of its water to flow out. This expelled water, as might naturally be expected, was saturated with the soluble nutritive ingredients of flesh—it was, in fact, juice of flesh—soup—with all its valuable and restorative properties. In the large curing establishments of this city very considerable quantities of this brine were produced, and thrown away as useless. This was the material to which Mr. Whitelaw has applied the process of dialysis, and he thought with success, for the removal of the salts of the brine, and for the production at a cheap rate of pure fresh extract of meat. His process he stated as follows:—The brine, after being filtered to free it from any particles of flesh or other mechanical impurities it might contain, was then subjected to the operation of dialysis. The vessels or bags in which he conducted the ope-

rations might be made of various materials and of many shapes, but whatever might be their material or shape he called them "dialysers." Such an apparatus as the following would be found to answer the purpose:—A square vat made of a frame work of iron filled up with sheets of skin or parchment paper in such a way as to be water-tight, and strengthened if necessary by stays or straps of metal. The sides, ends, and bottom being composed of this soft, dialysing material, exposed a great surface to the action of the water contained in an outer vat, in which the dialyser was placed. He found a series of ox bladders fitted with stop-cocks, or gutta percha mouth tubes, and plugs, and hung on rods stretching across and into vats of water, a very cheap and effective arrangement. He could also employ skins of animals, either as open bags or closed, and fitted with stop-cocks, or bags of double cloth, with a layer of soft gelatine interspersed between them. Other arrangements would readily suggest themselves, and might be adopted according to circumstances. But supposing the bladder arrangement were taken, which, he thought, would be found practically the best, being cheap, easily managed, and exposing a great surface to the dialytic action. The bladders were filled with the filtered brine by means of fillers, and hung in rows on poles across, and suspended into vats of water. The water in those vats was renewed once a day, or oftener if required, and he found that actually at the end of the third or fourth day, according to the size of the bladders employed, almost all the common salt and nitre of the brine had been removed, and that the liquid contained in the bladders was pure juice of flesh in a fresh and wholesome condition. The juice as obtained from the "dialysers," might now be employed in making rich soups without any further preparation, or it might be concentrated by evaporation to the state of solid extract of meat. The liquid from the dialysers might be treated in several ways. It might be evaporated in an enamelled vessel to a more or less concentrated state, or to dryness, and in these various conditions packed in tins or jars for sale. It might be concentrated at a temperature of 120°, by means of a vacuum-pan or other suitable contrivance, so as to retain the albumen and other matters in a soluble form. Again, the more or less concentrated liquid might be used along with flour used in the manufacture of meat biscuits. The products he had named were all highly nutritive, portable, and admirably adapted for the use of hospitals, for an army in the field, and for ships' stores. The dialysis of brine might be conducted in salt water, so as to remove the greater portion of its salt, and the process completed in a small quantity of fresh rain or other water. In this way ships at sea might economize their brine, and so restore to the meat in a great measure the nutritive power that it had lost in the process of salting. Thus, then, Mr. Whitelaw obtained an extract of flesh at a cheap rate, from a hitherto waste material. Two gallons of brine yielded one pound of solid extract, containing the coagulated albumen and coloring matter. For the production of the same directly from meat, something like twenty pounds of lean beef would be required. The quantity of brine annually wasted was very great. He believed he was considerably under the truth

when he said that in Glasgow alone 60,000 gallons were thrown away yearly. If they estimated one gallon as equal to seven pounds of meat in soup producing-power, then this was equal to a yearly waste of 187 tons of meat without bone. Estimating the meat as worth six-pence per pound, this amounted to a loss of £10,472. In this way the waste over the country must be very great. In the great American curing establishments the brine wasted must be something enormous, as he found that in eight of the Federal States 4,000,000 pigs were slaughtered and cured last season. Mr. Whitelaw concluded by quoting from Gregory and Liebig as to the value and efficacy of extract of meat.

New mode of Illumination.

From the London Chemical News, No. 225.

M. Soubra, a Professor of Mathematics, has invented a new method of illumination, or rather a method of inverting a flame by the adoption of which several advantages are expected to be realized. The apparatus consists of a syphon of glass, the open ends of which are turned upwards; a burner is placed just within the shorter branch. Before lighting the lamp, the longer branch of the syphon, is heated and a current of air established, which carries with it any flame placed at the open end of the shorter branch, the flame, consequently becoming inverted. As soon as the current is established, and the burner kindled, the heating of the longer leg may be discontinued, the current, once established, being sustained by the heat from the inverted flame. The advantages of this new arrangement are as follows:—The supports of the globes or lamp-glasses are placed above the flame, and do not intercept the light; the reflectors, also are in no danger of becoming blackened by smoke, and they collect rays that otherwise would be lost in the air. The flame has a more elevated temperature on account of the heat being concentrated by the syphon, and the carbon consequently more incandescent. The products of combustion are collected in the syphon, and may be conveyed away instead of vitiating the air of the apartment. It is proposed to employ these reversed flames as foot-lights for theatres, the advantages, such as safety, &c., being obvious.

Translated for the Journal of the Franklin Institute.

Water-proof Mortar.

M. Pavesi of Mortara, recommends for the protection of houses against dampness, to cover the walls with a plaster composed as follows: 4 parts of pounded glass, 3 parts of charcoal or coal, 2 parts of pomice-stone, 3 parts of tar, 2 parts of pitch, 1 part of boiled linseed oil. These substances are mixed in a cast iron pot, and moderately heated until they form a homogeneous paste. It is then to be applied to the wall and sprinkled with sand for the purpose of holding the lime which is to be applied over it. This mortar is recommended by its efficiency, cheapness, and easy preparation.—*Cosmos.*

Of the Supposed Nature of Air prior to the Discovery of Oxygen.

By GEORGE F. RODWELL, F.C.S.

From the London Chemical News, No. 196.

1. *The Pneumatics of the Ancients.*—In the earliest ages of which we have any record the idea that the four elements—earth, water, air, and fire—were first created, and the whole world produced from them, seems to have prevailed. We conceive this to have been the oldest physical theory; it was believed by different races in various parts of the world; indeed, it is probable that it originated before the time of the Arian migration. Races which differed from each other in every respect in which they could differ—in habits, in power of thought, in religion—all admitted this theory. The philosophy of every age is pervaded by it, and it endured longer than any succeeding hypothesis; for a century ago it was not as yet disproved.

We can quite understand how this thought came to fix itself so early and so permanently in the human mind. In every age, in every country, we find some men who possess a spirit of inquiry, who desire to understand all they can about the world in which they live, and to account for the various phenomena they see around them. In this same spirit did the first philosopher ask himself, "What is the world?" Throughout Nature he found but four distinct entities, and was it not natural to think the whole world was composed of them alone? Gross earth, to which he could refer all solids; more mobile water; scarcely perceptible air, with which he classed winds, and clouds, and his own breath; and lastly, subtile, intangible fire, type and symbol of the sun which he worshipped, first as an emblem of the Deity, but afterwards as himself a god.

In several systems of philosophy the air was made chief of the elements; from it the other three proceeded, and from all four the world. Kanáda, who founded the Nyaya system of Hindu philosophy, at a period long prior to the rise of Greek physical thought, taught that all material substances exist first as atoms, then as aggregates. "When atoms are separated, dissolution of the world takes place; at its renovation the atoms come together again to form air, then fire, next water, afterwards earth, then the body and its organs, and ultimately the whole world."* The distinguishing feature of air, he tells us, is its being neither hot nor cold; it possesses, moreover, "faculty of elasticity and velocity."

In each of the three ancient schools of Hindu philosophy a fifth element, the "ether occupying space," was introduced; it was supposed to be the vehicle of sound, which some said was propagated by waves. It is difficult to understand in what light the ether was viewed by the San'chya and Nyaya schools, but according to the Vedanta (a system which followed that of Kanáda), the ether was air at rest, and the "air" wind or air in motion. Ether and air, we are told, were first created by Brahme, and fire, water, and earth produced in succession, the one

* Colebrook "Philosophy of the Hindus."

from the other. Thus air would be evolved from ether, and fire from air.

In both the Nyaya and Vedanta systems fire is said to be produced from air, and this idea probably arose from the knowledge of the necessity of air to fire. The first fire was in all probability produced by the friction of two pieces of wood, for this method is mentioned in the earliest hymns of the Rig Veda, the oldest book in the world next to the Pentateuch. The first man who produced fire by friction must have observed how the ignited wood glowed when he moved it quickly through the air, or when the air blew upon it; and, in order to convert the first produced spark into a flame, he would in future blow upon it, for since wind increased the energy of fire, it seemed likely that the breath, which felt like wind, would also increase it; and soon a reed tipped with metal would be used to concentrate the breath on one spot, in cases where great heat was required. We find such reeds were used by the Egyptian workers in metal as early as the time of Abraham;* they were afterwards superseded by pointed metal tubes. But the use of a mouth blow-pipe was laborious, and it could not be used for large fires or smelting operations; hence men set about finding something which should take the place of the lungs, and in their search they were probably helped by the makers of leather bottles; for these latter could not fail to observe that when a bottle was squeezed a blast of air rushed from its mouth, and by making a hole at the opposite end to the mouth, closing this when the bottle was compressed, and opening it to admit the air before a second compression, a tolerably continuous blast could be produced. Hence arose the invention of bellows. These primitive bellows seem to have been improved at a very early date by the Egyptians, for Sir Gardiner Wilkinson believes he has found indications of a valve by which air was admitted to the bellows as early as the time of Moses.

Let us next turn our attention to the ideas of some of the Greek philosophers in reference to the air.

Anaximenes, of Miletus (born B.C. 529), taught that the air was the beginning of things, from which every thing had been produced, and into which every thing would be resolved.† The earth was a trapezium supported by the air.

Air when rarefied becomes fire; when condensed, winds and clouds; more condensed, water; and condensed to its greatest extent, earth and stones.

According to Plutarch, Anaximenes "called the contraction and condensation of matter cold; the laxity and rarity thereof heat."

Anaxagoras (born B.C. 499) held that the earth occupies the lowest place among the elements, fire the highest, while water and air are midway between them. Winds are produced by the rarefaction of the air by the sun's heat. Anaxagoras maintained that there was no vacuum, for although in a blown bladder there is an apparent void, yet if we press it the resistance proves that something material is within.

* Sir G. Wilkinson's "Manners and Customs of the Ancient Egyptians."

† Ritter's "History of Philosophy."

The early physicists contented themselves with upholding their opinions by reasoning alone, and seldom resorted to experimental proof, and, so far as we are aware, this is the first recorded example of an experiment being introduced to prove an assertion.

Plato (born 429 B.C.) propounded a theory of respiration which is worthy of notice. "We breathe," he says, "after this manner. The external air compasseth us round about, and passeth in at our mouth, nostrils, and invisible pores of the body, where, being warmed, it floweth back again to the external air; by that part out of which it floweth, it again thrusteth the external air to the interior. Thus there is an unintermitted succession of inspiration and expiration."*

Zeno, the founder of the Stoics (born B.C. 362,) maintained that fire is present every where; that it is in water is proved by the fact that water is susceptible of greater cold. "It is consequently in air also, that being a vapor extracted from water, and supplied by motion of the heat which is in the water."

Chrysippus, a follower of Zeno, taught that air is divided into three regions; the highest, next to the sphere of the moon, is the hottest and most rarefied, because of the vicinity of fire; the middle region is coldest, and in it winds and clouds take their rise; the lowest region is thick, on account of the exhalations which it receives from the earth.

According to the Stoics, the elemental fire when condensed becomes air; further condensed, water; water rarefied becomes air; condensed, it produces earth. Earth is the centre of all; it is surrounded by water, this by air, and the air by fire. The Stoics believed that sound is air set in motion, and spreading its circles, like those which are produced when a stone is thrown into water.

Aristotle (born B.C 384) wrote a number of treatises on Physics, and the theories which he propounded, and the explanations which he gave of various phenomena, were almost universally admitted till the time of Galileo, and many of them till a much later period. Galileo was the first who ventured to oppose Aristotle's philosophy, and he met with much opposition, and had many obstacles to overcome before he could induce philosophers to give up any of the teachings of the master they had so long followed.

According to Aristotle† the earth is a sphere, enclosed by a sphere of water, this by one of air, and the air by fire. There is a fifth element, the ether reaching as far as the moon, but also contained within living creatures, for vital heat is not actual fire.

Each of the four elements was distinguished by two properties, and one attribute of each was common to another element; thus:—

Fire is hot and dry.
Air is hot and moist.
Water is cold and moist.
Earth is cold and dry.

Air is said to be hot and moist because Aristotle thought that it was

* Stanley's "History of Philosophy."
† The works of Aristotle, translated by Thomas Taylor.

produced from water by heat, and this was believed for many succeeding centuries.

The elements were capable of being converted the one into the other, if (said Aristotle) the dry of fire is vanquished by moist, air will be produced; if the hot of air is vanquished by cold, water will be generated from air; so fire is generated from air and earth, for "flame is especially fire, but flame is burning smoke, and smoke is from air and earth."

Aristotle did not admit Plato's theory of respiration, but conceived that air is received into the heart and acts by cooling the blood. Animals are suffocated in a confined space, because the air rapidly becomes hot, and can no longer cool the blood.

There is no vacuum. Air is a material substance, possessing weight, and every where present. That it possesses weight is proved by the fact that a bladder when inflated weighs more than it did before inflation. Simplicius, a philosopher of the sixth century, the commentator of Aristotle's works, tells us that Ptolemy, the mathematician, states that neither water nor air have any weight "in their own places," by which we suppose he means air weighed in air, and water in water. Ptolemy's experiments did not confirm those of Aristotle, for he found that a bladder weighed less after inflation than before.

Simplicius, from the most accurate experiments he was able to make, found that an inflated bladder weighed the same as before inflation, and adds that Aristotle probably filled the bladder he used by blowing into it, and thus introducing very moist air.

And this was probably the case, for a bladder weighed in air weighs the same before inflation with air as after. According to the theorem of Archimedes, a body immersed in a liquid loses a portion of its weight equal to the weight of the liquid which it displaces; hence an uninflated bladder weighed in air loses a weight equal to the weight of air which it displaces; the same bladder inflated and weighed under similar conditions loses the same weight as before, plus the weight of air which the air within it displaces; but the air it contains obviously displaces as much air as its own volume occupies, *i.e.*, a weight of air equal to its own weight; therefore the bladder must weigh the same whether inflated or empty.

The principal physical properties of the air known to the ancients, and the mechanical contrivances which work by means of rarefied or compressed air are given us by Hero, of Alexandria.

Hero, who flourished about (177 B.C.,) was the author of a treatise on pneumatics, which is believed by many to be a compilation from older works.

We must all admit, he says, * that air is matter, because if we invert the open end of a vessel having but one opening in water, we find that the water does not enter, but if a hole is now bored in the upper part of the vessel, the water rushes in and the air escapes, as may be felt, for if we place our hand over the orifice we perceive a rush of wind, which is moving air.

Hero was well aware of the elasticity of the air, for he tells us, there

* "The pneumatics of Hero, of Alexandria," translated by Bennett Woodcroft.

are void spaces between the particles of air, just as there is air between the particles of sand on the sea shore; when the air suffers compression the particles are forced into the vacant spaces, and when the pressure is removed they return again to their former position on account of their elasticity, just as horn shavings or sponge would under similar circumstances.

In speaking of the way in which cupping-glasses act, Hero tell us that the fire which is made to burn within them consumes and rarefies the air, in the same way that water is rarefied by fire and caused to become air.

A great number of the appliances which Hero mentions work directly or indirectly by means of a siphon. The siphon is an instrument of very ancient invention. Sir G. Wilkinson states that it was known in Egypt in the time of Amunoph II., (B.C. 1450.) The water of the Nile is muddy, and it is necessary to allow the sediment to deposit before drinking it. A reed was sometimes used to suck out the supernatant fluid, and it probably happened long ages ago that a man sucked out the water by a bent reed, and found to his suprise that the water continued to run after the sucking had ceased, and in this way perhaps the siphon was first discovered. The name siphon is derived from an oriental word signifying "to suck out with the breath."

According to Hero, a liquid rises in one leg of a siphon when suction is applied to the other, because when we have sucked out the air we become fuller than before, pressure is exerted on the air near us, it is communicated to the liquid in which the siphon is immersed, and compels it to rise in one leg of the instrument to fill the void space therein.

Among other inventions, we find that of a water-jet acting by compressed air. A strong globe of metal has a pipe fitted to it, reaching nearly to the bottom of the vessel, and terminating above in a jet, capable of being closed or opened at pleasure. In a small aperture in the globe a tube containing a valve opening inwards is placed; a solid plunger works in the tube, by which air is forced into the globe. It is obvious that the plunger had to be removed from the tube after each stroke, to allow air to re-enter. When a quantity of air was forced into the vessel the jet was opened, and the water rose to a considerable height. The valve consisted of two square pieces of bronze about three-fourths of an inch in the side, the surfaces of which were ground so that neither air nor water could get between them when closed. An orifice one-third of an inch in diameter was made in one of them, and they were united by a hinge.

A machine for raising water is described very similar to our modern fire-engine. Two cylinders of metal open above, and having below spherical metal valves opening inwards, are placed in water. From the cylinders proceed two pipes, which communicate with a third vessel by means of valves opening within it. To this vessel a long pipe is fitted. The cylinders are supplied with solid plungers, which when worked will obviously force water from the cistern through the long pipe.

Under the title of "a water-jet actuated by compressed air from the lungs," Hero mentions an arrangement exactly similar to an ordinary wash bottle, except as regards the tubes, which are both vertical.

A number of very ingenious contrivances, worked for the most part by compressed air, fill up a great part of Hero's pneumatics. Many of these are of no practical use, but remind one more of conjurors' tricks than of mechanical appliances. Take the following as examples:—

"A steam boiler, from which either a hot blast may be driven into the fire, a black-bird made to sing, or a Triton to blow a horn."

"An automaton, the head of which continues attached to the body after a knife has entered the neck at one side, passed completely through it, and out at the other. The animal will drink immediately after the operation."

(To be Continued.)

Monster Steam Hammer.

From the Journal of the Society of Arts, No. 593.

Messrs. R. and W. Morrison, of Newcastle-on-Tyne, have just forged what is believed to be the largest and most powerful steam hammer in the world, for the Russian Government. The piston-rod, to which the hammer is attached, weighed no less than 42 tons in its rough forged state, and now, when dressed down to the required dimensions, it has only been reduced to 35 tons. The length of the piston-rod is 38 ft., the diameter 2 ft. 4 ins., having a stroke of 14 ft. 6 ins., the piston being 6 ft. 8 ins. The forging of this mass of metal occupied 44 days. The cylinder for this hammer was cast at the Elswick Engine Works. Its diameter inside is 6 ft. 8 ins., its weight upwards of 40 tons. The two standards weigh nearly 40 tons each.

On Artificial Illumination. By EDWARD FRANKLAND, Esq., F. R. S.

Ten years ago the speaker gave in this Institution a sketch of the condition of Artificial Illumination. Since that period but little progress had been made towards perfecting those processes of producing artificial light at that time in general use. Nevertheless, the improvements effected in the production and application of the electric light, the increase of our knowledge both of solar and terrestrial light, and especially the discovery of an entirely new illuminating agent, threatening to produce a revolution in lighting almost equal to that which was the result of the invention of gas—rendered it desirable again to review this subject after the lapse of a decade.

In glancing at the improvements effected in the different departments of artificial illumination, those which relate to the electric light were first noticed. The electric light is produced by the interruption of an electric current flowing through good conductors; by this interruption the current is made to leap across a space provided in its circuit. The boundaries of this space, in the ordinary electric light, are formed by two portions of gas carbon, and during the passage of the electric current across it, the two pieces of carbon are heated to a most intense

degree, and far beyond that produced by any other means at our disposal. The great scource of illuminating power was shown to be the ignited ends of these two pieces of gas carbon, and not the space between them.

Such being the nature of the electric light, the principal improvement which has been effected in it, during the past ten years, consists in the production of the electric current through the intervention of heat and mechanical force, by what is termed magneto-electricity. More than thirty years ago, Mr. Faraday produced a spark from the ordinary permanent magnet. Here, said the speaker (producing a magnet) is the very cradle of this magneto-electric light, and this is the very magnet with which Mr. Faraday operated. This improvement constitutes one of the greatest steps in advance which have been made in the application and production of the electric light. By the combustion of coal a certain amount of mechanical power is obtained, which is applied to the rotation of masses of iron in the neighborhood of very powerful permanent magnets. In this way, currents of electricity are produced, and these are thrown together, and made to circulate through a system of conductors: in fact there is no difference, as regards the effect at the carbon-prisms, between the action of this magneto-electric current, and the ordinary electric current produced by the chemical action which takes place in the voltaic battery. But this improved mode of producing the electric force demands less manual labor; the mechanical work being performed by a steam engine, which causes the rotation of the armatures.

This magneto-electric apparatus, as perfected by Mr. Holmes, has now been in use for upwards of two years in the South Foreland and Dungeness lighthouses, where, as well as in other similar beacons, the production of a light of the greatest intensity is of the greatest importance to the mariner. During this time it has performed its office remarkably well, and without a single instance of failure; thus proving itself well adapted for the purposes of lighthouse illumination.

For domestic light it has not yet been brought into use; its expense, doubtless, at the present moment, being far too great to admit of its being employed in this way: but where a light of great intensity, regardless almost of the question of expense, is required, as in the case of lighthouses, this magneto-electric light can scarcely be too much prized.

The speaker also described the mercurial electric light, but considered it inferior both in brilliancy and steadiness to that procured by the passage of the electric current between carbon terminals.

The discoveries and improvements connected with gas as an illuminating agent were then considered. It is of great importance that gas, as a light-giving material, should be improved to the utmost possible extent, so as to make it a perfect source of light. Its conveniences are so patent to every one, its use is attended with so few discomforts, and the light is obtained with such facility, and of any desired intensity within certain limits, that there is, perhaps, no source of artificial light capable of such general application. Nevertheless, this is one

of the modes of illumination which, having been long previously in use, have not made great progress during the past ten years. The sulphur compounds, which at the commencement of that time were complained of as being present in purified gas, are still there in considerable, if not in undiminished quantity, although there has recently been a process devised by means of which these impurities can be, to a great extent, got rid of. It remains to be seen whether this process be applicable, on a large scale, in the gas manufactory; but, so far as can be judged from experiments made upon a small scale, it is a process which is likely to be very effective. It is the invention of the Rev. Mr. Bowditch, of Wakefield. These sulphur compounds are irremovable in the ordinary process of purification. The gas may be passed in the usual manner over hydrate of lime, or the peroxide of iron; but this operation does not, in the slightest degree, affect the sulphur compounds in question. During the combustion of the gas, however, their sulphur is converted into sulphurous acid, which diffuses itself into the apartment in which the gas is burned, and a great deal of the discomfort of which many complain in the use of gas is due to this cause. Mr. Bowditch discovered that though cold hydrate of lime will not remove these impurities, they are to a great extent got rid of by heating the hydrate of lime to a temperature varying from the boiling point of water up to 400° or 500° Fahr., a temperature of 400° being the most convenient for the development of the effects of his process. The heated hydrate of lime converts the sulphur compounds into sulphuretted hydrogen and carbonic acid, which can then be removed by the ordinary purifying material—cold hydrate of lime. This process has been found by repeated experiments to remove all but about 2 or 3 grains of sulphur per 100 cubic feet of gas, the quantity of sulphur originally contained in the gas varying from 5 or 6 grains up to 20 grains in 100 cubic feet. Heated hydrate of lime was shown to develop sulphuretted hydrogen from the gas supplied to the Institution.

Another recently ascertained fact in connexion with gas is the discovery of a new illuminating constituent recently made by M. Berthelot. This is a gaseous body, called acetylene, which is produced under very peculiar circumstances. Unlike all other hydrocarbons with which we were formerly acquainted, an intense heat is favorable to the production of this body. For instance, it is produced when coke is very intensely ignited in hydrogen gas; and Dr. Odling has recently demonstrated that two of the constituents of coal-gas, light carburetted hydrogen and carbonic oxide, which are useless for lighting purposes, may, by means of strong ignition, be made to form acetylene, and thus become luminiferous agents. It has generally been considered important to preserve a moderate degree of heat in gas-making in order to prevent the destruction of the luminiferous hydrocarbons; but the discovery of the formation of acetylene, under the circumstances named, will render it necessary to investigate how far the production of this substance can be carried on upon a large scale, and rendered valuable for increasing the illuminating power of gas. The subject is yet in embryo; but it has an important bearing upon the future progress of gas-

lighting. Acetylene and olefiant gas contain, in equal volumes, the same amount of carbon, but the former contains only half as much hydrogen as the latter; consequently, the illuminating power of acetylene is probably at least double that of olefiant gas.

The compound of acetylene with copper, is a substance not altogether devoid of interest to the gas manufacturer. When it attains a certain heat, it explodes with considerable violence, and the same effect may be produced by friction. It has been demonstrated recently, that acetylide of copper can be produced by the passage of ordinary coal-gas, containing, as it does, a trace of ammonia, through copper or brass tubes; and explosions which have taken place through cleaning out such tubes, resulting in serious injury to workmen, have been doubtless due to the presence of this substance. It is, of course, obvious that an explosion of this kind, even if slight in itself, may be communicated to explosive mixtures of gas and air (in a gas-holder or gas-meter, for instance). and may thus lead to very disastrous results. An explosion of this kind occurred a few years ago in Lancashire. A large meter had been detached, and brought into the open air; a workman was unscrewing one of the brass connexions, when the meter exploded with a loud report. The explosion could not be accounted for, as all the eye-witnesses were positive that no ignited body of any kind was near the meter.

The improvements effected in the production and application of oils for illuminating purposes were next referred to.

The animal and vegetable oils, which for ages have been employed for this purpose, have received no development of importance during the last ten years. On the other hand, new sources of this class of illuminants have been discovered, which threaten to produce a great revolution in the modes of obtaining artificial light.

One of the most important of the materials manufactured from these sources is pariffin oil, the production of which from bog coal has been carried out on an immense scale with great ingenuity and success by Mr. Young, of Bathgate, near Edinburgh. [The speaker here exhibited several lamps fed with this oil.] This new source of light is however already threatened by a formidable rival—native coal oil—which has been distilled by nature herself, and consequently does not require those preliminary processes which oil produced from bituminous coal has to undergo. These discoveries have been made principally in the United States of America, and more especially in Canada. In the latter country alone no less than twenty millions of gallons of this oil have been obtained from wells, several of which are spouting-wells. From these the oil rises, probably from the pressure of gas, to a considerable height above the surface of the ground, so as not to require pumping. The twenty millions of gallons, which represent the annual production of the Canadian wells, may, upon a moderate calculation, be said to furnish, in refined oil alone, illuminating material equal to one hundred and eighty millions of pounds of sperm candles.

The importance of such a vast amount of illuminating material so

cheaply obtained can scarcely be overrated in connexion with the question of the production of artificial light. Up to the present time, the refined oil from this crude petroleum (specimens of which were exhibited) has been prevented from coming into effective competition with the original paraffin oil, owing to the carelessness with which the former has been manufactured. There is a considerable portion of light naphtha left in this oil, which renders it capable of forming explosive mixtures in the lamps wherein it is burned. Both these American oils require to be still further freed from volatile naphtha. They would then form valuable illuminating materials.

The speaker then directed attention to the following tables. The first contains the results of his experiments on the illuminating effect of these oils in connexion with that of some other materials used for giving artificial light:—

Illuminating Equivalents, or the Quantities of different Illuminating Materials necessary to Produce the same amount of Light.

Young's Paraffin oil,	1	gallon.
American rock oil, No. 1,	1·26	"
do. No. 2,	1·30	"
Paraffin candles,	18·6	lbs.
Sperm do.	22·9	"
Wax do.	26·4	"
Stearic do.	27·6	"
Composite do.	29·5	"
Tallow,	36	"

From this table was made the following calculation of the comparative cost, from different sources, of the light of twenty spermaceti candles, each burning for ten hours, at the rate of 120 grains per hour:—

	s.	*d.*
Wax,	7	2½
Spermaceti,	6	8
Tallow,	2	8
Sperm oil,	1	10
Coal gas,	0	4½
Cannel gas,	0	3
Paraffin,	3	10
Paraffin oil,	0	5
Rock oil,	0	6½

Thus, from an economical point of view, the rock oil and the paraffin oil approach gas much more closely than any other illuminating agent hitherto invented; while the enormous quantities in which these oils are now being produced cannot fail to make them still lower in price. They may consequently be regarded as very formidable rivals of gas-light.

The following table contains the amount of carbonic acid and heat

generated per hour by various illuminating agents, each giving the light of twenty sperm candles:—

	Carbonic acid.	Heat.
Tallow,	10·1 cubic feet	100
Spermaceti, Wax,	8·3 "	82
Paraffin,	6·7 "	66
Coal gas,	5·0 "	47
Cannel gas,	4·0 "	32
Paraffin oil, Rock oil,	3·0 "	29

This table shows to what extent the atmosphere of rooms is deteriorated by these illuminating agents. It shows also that, from this point of view, paraffin and rock oils stand out as the best sources of light.

The chemical and physical laws upon which all modes of artificial illumination depend were then referred to. Every method of artificial illumination depends upon the heating of certain bodies to such a temperature that they become incandescent. With gases this temperature is much higher than with liquids or solids. There is only one instance in which the incandescence of vapor is used, and that is the mercurial electric light, already alluded to. In all other cases the incandescence of solid bodies is employed. In the ordinary method of obtaining the electric light, the incandescence of solid prisms of carbon is the source of luminosity. In gas and oil flames, it is the incandescence of little particles of carbon, and in all these cases the light is produced from solid matter. The luminosity of any flame depends, first, upon the number of solid particles which exist in it at any given moment; and, secondly, upon the temperature of the flame. The number of solid particles is dependent upon the nature of the flame itself, whether it be a flame produced by the burning of bodies rich in hydrocarbons, or by the burning of bodies which are poorer in this respect. Such a flame is always affected by the pressure of the atmosphere. The higher the pressure of the air, the greater the number of luminous particles of carbon present at one time in the flame. If, after the barometer has been standing at 30 inches, it falls to 29 inches, the light of all flames is reduced to the extent of about 5 per cent. The temperature, upon which the luminosity of a flame also depends, may be increased by heating both the gas and the air supplied to it for combustion, before they are brought together to be burned.

The speaker exhibited a gas lamp which he had constructed to effect this object. It consisted of an ordinary Argand burner, with glass chimney, but furnished with an outer glass cylinder resting upon a solid plate of glass, through the centre of which the tube supplying the gas rose. Thus all the air supplied to the flame was compelled to pass down between the chimney and outer cylinder, becoming thereby strongly heated before it reached the flame, whilst considerable heat was also imparted to the gas before the latter issued from the burner. In this manner a great increase of light, with the same consumption of gas, was obtained.

The following table was exhibited, showing the effect of this hot air gas-burner in reducing the consumption of gas for a given amount of light, and thereby also the impurities and heat which are thrown into the atmosphere in which such a lamp is burned:—

	Rate of consumption per hour.	Illuminating power.
Argand burner supplied with cold air,	3·3 cubic feet,	13 Sperm candles.
	3·7 "	15·5 "
	4·2 "	17 "
Same burner supplied with hot air,	2·2 "	13 "
	2·6 "	15·5 "
	2·7 "	16·7 "
	3·0 "	19·7 "
	3·3 "	21·7 "

For an equal amount of light, the saving of gas = 33 per cent. For an equal consumption of gas, the gain in light = 62 per cent.

The temperature necessary to render substances incandescent may be imparted to them in various ways. It may be given directly by mechanical power, as in the "steel mill," formerly used in coal mines. Usually, however, chemical action is employed, as in gas, candle, and oil flames; or electricity is used, as in the various forms of electric light.

The conditions necessary for a good and satisfactory artificial light were now examined. In the first place, the light should contain all colors; that is, it should be capable of showing every variety of tint which will be exposed to it. This is the case with the carbon electric light, and that candle, oil, and gas flames, since the light from these sources contains all the colors of the spectrum. But there are many colors which the mercurial electric light is incapable of showing, since they are absent from its spectrum. It was also shown that all pure colors, except yellow, were perfectly black, when seen by the light of incandescent sodium vapor.

Solar light, although in so many respects superior to artificial light, is defective as regards the showing of colors. There are certain colors which cannot be seen by solar light—for instance, all the color which can be seen by the sodium flame is quite invisible in daylight. If a pigment could be made of such a yellow color as to be of exactly the shade of that produced by the sodium flame it would be absolutely black in solar light. But our pigments are all mixed colors, and no such pigment which thus entirely disappears in the light of the sun is known. But in addition to this tint of the sodium flame, there are hundreds of other tints which are also not present in the solar spectrum, and which are consequently invisible in daylight.

Although solar light is inferior to artificial light in the completeness of its colors, yet, in another respect—in the comparatively small amount of heat which accompanies its rays in proportion to the light itself—it is greatly superior to every sort of artificial light. The great amount of heat in our artificial lights is absolutely useless. It is nearly all intercepted by the humors of the eye before it reaches the retina, and, no doubt, produces that irksomeness which is felt after working

in artificial light for any considerable time, and which is not experienced from daylight.

The speaker concluded as follows:—The history of artificial illumination cannot fail to impress upon us the difficulties in the way of the application of scientific discovery to the utilities of life. How long was it after the discovery of the production of gas from coal, before a manufacturer could be found to bring it into actual operation? Thirty years ago working in his laboratory at Blansko, Reichenbach showed us the process by which we could obtain paraffin and paraffin oil from bituminous coal; but the discovery remained unheeded for twenty years. More than thirty years ago, Mr. Faraday pointed out a source of the electric light in the permanent magnet; but we are only now beginning to use it for illuminating purposes. The brilliant little spark was long looked upon as a mere scientific curiosity, and is only now beginning to flash across the sea, guiding the mariner safely into harbor, or warning him from approaching a dangerous coast. How long will thermo-electricity have to wait before it receives a similar application? In thermo-electricity we have a direct transformation of the force of heat which we obtain with such great economy from coal, into an electric current, and this, by further education and development, might be rendered available in the production of the electric light. Hitherto, its application in this direction has been altogether unheeded, and yet of all sources of the power necessary for the electric light, thermo-electricity evokes this power most directly from coal. In the magneto-electric light we have the great disadvantage, that the heat of burning coal must be first transformed into mechanical power, which is made to rotate the armatures of magnets, and thus produce the necessary electric current. In this transformation of heat into mechanical power there is no less than $\frac{9}{10}$ths of the original force in the coal absolutely lost. Hence the advantage which would result from the direct application of heat to the production of the electric current.

The man of science rejoices in the discovery of truth for its own sake. He gives his results freely to the world. It is no part of his duty, it is not his function, to apply those truths to the utilities of life. Success in this direction demands quite different powers of mind. Those who possess these powers, ought also to acquire the necessary knowledge which would enable them, with more facility, to seize upon the discoveries of science, and apply them to the wants of every day life. This scientific knowledge is the link which, up to the present time, has so sadly failed in the application of science to the manufacturing arts.

Proc. Royal Inst., Feb. 13, 1863.

New Maximum Thermometer.

From the Journal of the Society of Arts, No. 593.

The novelty in this thermometer consists in the addition, near the bulb, of a small tube at right angles to the tube of the thermometer, and in connexion with the bore; and when the thermometer is placed horizontally, this tube stands perpendicularly above it. On an increase

of temperature taking place, the mercury will rise in the small bore, as in an ordinary thermometer; but on the temperature decreasing, instead of receding, in the small bore, as in an ordinary thermometer, the mercury in the bulb, on contracting, draws with it the mercury from the small side tube, and then the column of mercury in the small bore registers the maximum temperature. To reset the thermometer for future observation, lower the end near the bulb, and allow the mercury to fall until it fills the small tube at the side, then the thermometer shows the temperature at the time, and is set for future observation.

Description of the Harrison Cast Iron Boiler.

From the London Engineer, May, 1864.

The boiler about to be described has been constructed with reference to the foregoing considerations. It was the object of the inventor, Mr. Joseph Harrison, of Philadelphia, U.S., to provide great strength against bursting, and to obtain, also, a large extent of heating surface in proportion to the weight and external dimensions of the boiler. It was important, moreover, to obtain perfect circulation for the water. An experience of several years in America, and for upwards of two years in London and Manchester—in one case with a boiler supplying steam to the extent of 200 indicated horse-power—has proved that these objects, as well as other important advantages, have been secured. It will not be necessary to describe now the forms which the parts of the boiler received in the earlier experiments, several years ago, but these led to the adoption of hollow cast iron spheres, connected by hollow necks, and secured together by bolts, as shown in longitudinal elevation in Plate II. Each of the castings includes four spheres, each 8 ins. in external diameter, $\frac{3}{8}$in. thick, and connected by necks of 3 ins. opening. Each of these castings is called a "unit." Each "unit" of four spheres has eight openings, 3 ins. in internal diamater, the edges of these openings being faced up to a true surface, so as to bear fairly upon the corresponding faced surfaces of the adjoining "units." Each joint has a shoulder and socket, so as to "steady" the units in their place, and steam tight caps are provided to cover the external openings, while the whole series of units, forming a slab of rectangular or other form are held together by bolts of $1\frac{1}{4}$ ins. diameter; these bolts passing inside the "units" and through the water or steam which they contain. Although the arrangement is simple, it will be better understood from the drawings, and from the units exhibited to the meeting, than from a purely literal description. Each slab, of whatever number of units it may be formed may be regarded as a separate vessel, throughout which the water or steam can circulate freely, both vertically and longitudinally. Any number of slabs may be placed side by side, in the same fire place, and they are connected together by a feed water pipe at the bottom and by a steam pipe at the top. There are eight slabs in the width of the boiler shown in end elevation. The water level is usually maintained so that about two-thirds of the whole number of spheres will be constantly filled with

water, the remaining spheres forming a steam space. The full force of the heat is not allowed to come upon those of the spheres which contain only steam, but small fire-brick screens are so placed between the slabs a little below the water level, as to confine the direct action of the heat chiefly to the spheres filled with water. The upper spheres are at the same time enveloped in an atmosphere so hot as to insure the complete drying of the steam. The slabs are fixed with an amount of inclination, in the direction of their length, sufficient to insure the complete drainage of all the spheres when the boiler is blown out. This inclination serves, at the same time, to bring the largest body of water to where the action of the heat is most direct, and to provide the largest steam space over that part of the boiler where ebullition is probably least active. The earlier experiments have shown that, although the "units" may be bolted together into slabs of a total length of even 20ft., a length of 9ft. is preferable, as the strain upon the bolts is correspondingly less, and as, in the latter case, there is no observable tendency to sag, the complete tightness of the joints is thereby insured.

The spheres weigh each, about 22½ lbs., a "unit" of four spheres weighing rather more than 3 cwt. Thus there are as nearly as may be, one hundred spheres to the ton, and it has been the habit, thus far to rate the boilers by their weight, as a 4-ton boiler, an 18-ton boiler, &c. The nominal horse-power of the cast iron boiler may be generally taken as three times its weight in tons. Thus a 10-ton boiler may be rated as of 30 nominal horse-power, and from experiments it appears that a boiler of this weight may be counted upon to evaporate 40 cubic feet of water per hour, corresponding to about 80 indicated horse-power. Each sphere contains seven pints of water, a "unit" of four spheres containing 3½ gallons. The external surface of each sphere is rather more than 1¼ square feet, and the internal surface a little more than 1⅛ square feet. In round numbers it may be said that each sphere presents a square foot of heating surface, and contains a gallon of water; while a ton of one hundred spheres represents three nominal horse-power, the proportion of weight to power being about the same as in Lancashire boilers of the ordinary type.

It cannot be said that cast iron is, itself, a strong material for boilers, yet it will appear that, in the form already described, it affords greater absolute strength against bursting than is possessed by any form of plate-iron boiler now in use. The "units" are cast upon green sand cores so placed that they cannot alter their position in the flasks by any force short of what would be sufficient to crush them to pieces. The thickness of metal in the spheres is, therefore, every where uniform, as has been proved by breaking great numbers of "units" taken at random. In a unit of four spheres, each sphere having an internal diameter of 7¼ ins., the whole area of the plane in which a bursting pressure would act, is 220 square inches, while the least section of iron resisting this pressure, in the same plane, is 27½ square inches. The iron employed is an equal mixture of Glengarnock, Carnbroe, and scrap, a mixture selected for its free running quality, and which is

much used for small machinery castings. Its tensile strength may be safely taken at 5½ tons per square inch. At this rate the bursting strength of the units would be 1540 lbs., or nearly 14 cwt. per square inch. The first experiments actually made to test the bursting strength of the units was made upwards of two years ago, in Brussels, at the request of the Belgian Minister of Public Works. In this case a pressure of 98 atmospheres, or 1440 lbs. per square inch was applied. This was as high as the force pump employed could go, but the spheres were not burst. When recently in Manchester, the author desired that a further series of experiments might be made with the same object. The arrangements for this purpose could not be completed before he was compelled to return to London, but Mr. Beyer kindly allowed the experiments to be made at the Gorton Foundry, and he deputed Mr. R. H. Burnett, then engaged in that establishment, but who is now Locomotive Superintendent of the Metropolitan Railway, to conduct them. The first of these experiments need not be recorded, as it was made with a hydraulic press gauge registering up to 4 tons per square inch, but which was subsequently found to be most incorrect. A high pressure gauge of Schaffer and Budenberg's, graduated to 1000 lbs. was then attached, to one of the units to which the caps had been accurately ground, and a water pressure was then applied by means of a force pump. The pointer of the gauge passed the 1000 lbs. mark to an extent indicating from 1150 lbs. to 1200 lbs., but the spheres did not burst. The Schaffer gauge was then compared with a Bourdon gauge marked to 500 lbs., and up to this point the gauges agreed within 10 lbs. per square inch. From a calculation of the weight applied to the force pump lever, and from the dimensions of the pump, Mr. Burnett estimated that the total force applied was about 1470 lbs. per square inch. Another casting of four spheres was afterwards tested in the same way, the pointer of the Schaffer gauge passing far beyond the 1000 lbs. mark. In this instance three men, instead of two, as in the first trial, were put to work the pump, but the spheres did not burst. The castings were subsequently broken with a sledge, and showed a uniform thickness at all parts, and a good quality of iron.

A safety valve was then arranged with the intention of ascertaining the bursting strength of the spheres. The valve was, square ½ in. on a side, and, therefore, of ¼th square inch area. Its head was 1¼ ins. in diameter, and was ground carefully to its seat. The spheres were burst at a pressure calculated at 1850 lbs. per square inch, but on comparing the safety valve with a pressure gauge it appeared that water must have worked its way over the ground seating of the valve, and that the true pressure could have hardly been so much. The seat of the valve was then turned to a diameter of ⅜in., and the spheres were burst, at a calculated pressure of 1650 lbs. per square inch. Even here it was found that some water must have worked under the valve seating, thus exerting its pressure upon an area greater than one-fourth of one square inch. The experiments with the safety valve were not, therefore, altogether satisfactory, but there appeared no reason to doubt that the bursting pressure was not far short of 1500

lbs. per square inch. All these experiments were made upon castings having their covering caps ground carefully to them, and the bolts were only about 9 ins. long between the caps covering the opposite openings of the units. When, however, a slab of perhaps one hundred spheres is bolted together, the bolts being upwards of 9ft. in length, the application of a strain considerably below the bursting pressure so stretches the bolts as to cause the joints to open every where and relieve the pressure. In this way every joint becomes a safety valve. This never occurs with any practicable steam pressure, but it did take place in many of the earlier experiments made to burst the spheres, although leakage seldom commenced until a strain of nearly or quite half a ton per square inch had been applied.

All these experiments were made with new castings, and at the time they were made no other spheres could be had which had been more than twelve months in use; and the condition of these was clearly the same as when new. It would appear, therefore, that the boiler now described possesses the same factor of safety under a pressure of 225 lbs. per square inch as a 7ft. Lancashire boiler under a pressure of 50 lbs. If, however, one of the units of the cast iron boiler should burst it could not do more than empty itself, and open one or more 3 in. apertures into the units adjacent to it. If, however, an ordinary boiler cantaining, say, 20 tons of highly heated water in one compartment, should burst, the consequences would be most disastrous. In some of the earlier boilers of the kind now described the setting was such that an excessive strain was brought upon one or more joints, and here, in order to prevent leakage, the bolts had to be tightened with great force. In two or three cases castings forming a part of the boiler were thus cracked from one joint to another. The consequence was an escape of steam or water, but no further damage ensued. In one of these instances a unit, thus cracked, was worked continuously for three days; and it might perhaps have worked for a still longer time, but it was thought prudent, for obvious reasons, to replace it by a sound casting. No instance of a fracture has occurred in the cast iron boilers with the present mode of setting, and all the boilers of this kind yet erected are quite free from leaks at the joints.

It will be remembered that the bolts have a strength much beyond even that at which the units would burst. The bolts, however, are under a certain initial strain before any pressure is raised in the spheres. This amount of initial strain is known and under control, as, in screwing up the slabs, a 27-in. wrench is employed, and the strength of but one man is applied to it. If, however, a great strain be put upon the bolts, the crushing strength of the castings is found to be greater than the tensile strength of the bolt. In a series of experiments, made by Mr. Luders, a slab of units, bolted together to a length of 9ft. was screwed up with great force. A wrench, 10ft. in length, was employed, and the force of three men applied. In every case the castings were compressed to the extent of $\frac{1}{8}$in., when the bolt commenced to stretch, and after elongating 1$\frac{1}{2}$ins. it broke. This experiment was repeated twelve times with the same result, the castings

remaining uninjured. The castings, when laid loosely upon a brick pavement, require a powerful overhead blow, from a heavy sledge hammer, to break them. They may be heated in a forge to a bright cherry red color, and be then plunged in cold water without cracking. Some of these castings, now at the Museum of Patents, South Kensington, were thus heated and quenched seven times in succession, and they still give out a clear, ringing sound when sharply struck with a hammer. There is no doubt that the iron was most seriously injured by this treatment, yet it might have been expected that the spheres would have broken to pieces. In one case while heated to a bright red, the casting was half filled with cold water. The endurance of the spheres under this treatment is to be referred to their form, and to the tough quality of the metal from which they are cast. A sharp blow with the edge of a hammer indents the iron nearly the same as if it were boiler plate.

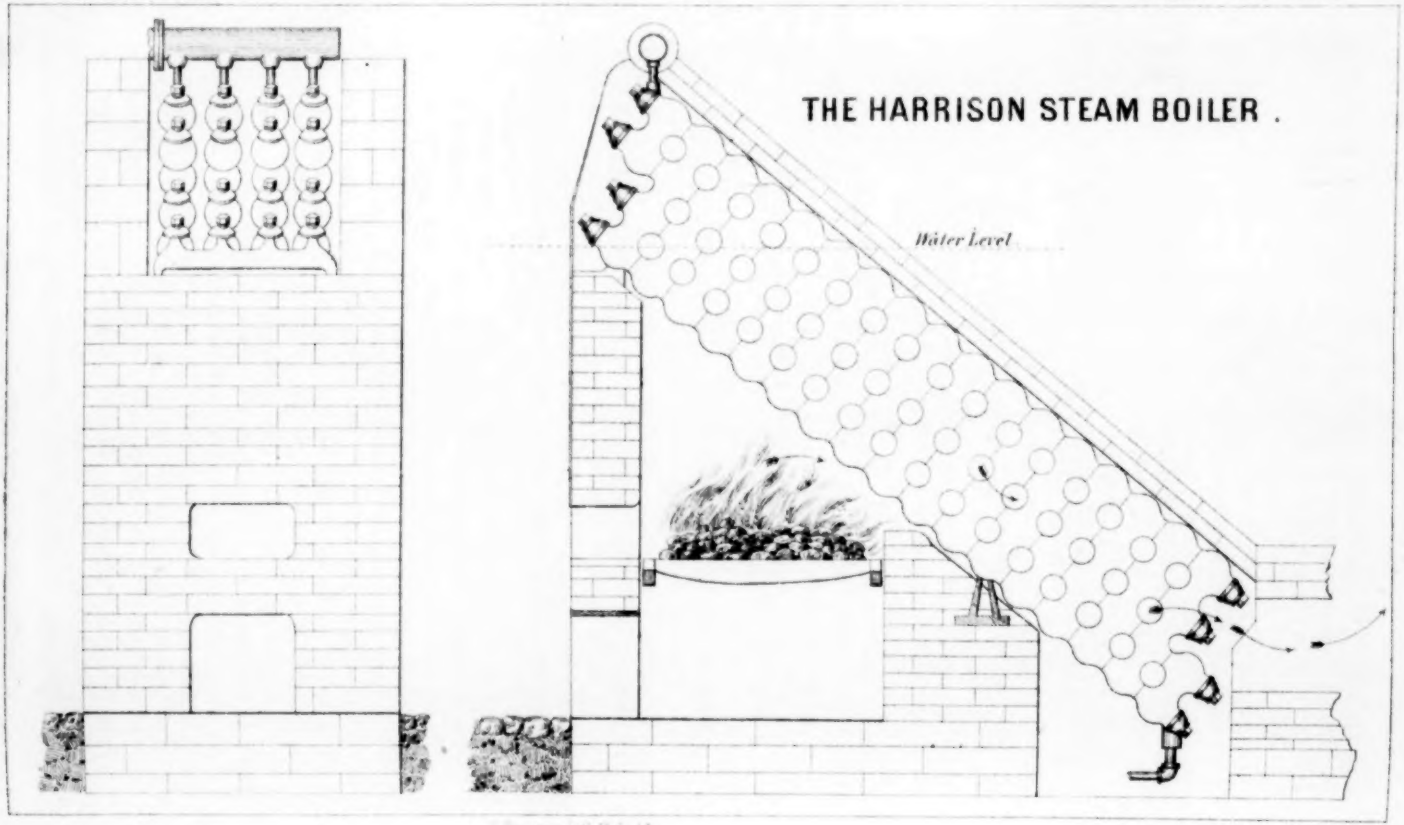
It might have been apprehended that the expansion of the castings, when in service in a boiler, would be such as to cause unequal strain upon the joints. No leakage at any of the joints of a single slab of castings can be detected, however; and as each slab is supported chiefly at its lower corner, and as all the slabs of a boiler are separate from each other, except at a single point above and below, where the steam and water connexions are respectively made, it is found that the slabs are under no injurious strain. All the spheres have, too, a considerable amount of elasticity under strain, which would assist in compensating for unequal expansion did it exist. These conclusions, as to the effect of expansion, are derived from an experience of two years and a half with a Harrison boiler, of 12-horse power, at the Chemical Works of Messrs. Denton, at Bow Common, London; two boilers—one of 50-horse and one of 12-horse power—at the Vulcan Works of Messrs. Hetherington and Sons, Manchester; and from a 12-horse boiler at the Harrison Boiler Works, Openshaw, Manchester. Messrs. Hetherington's boilers are often worked collectively up to 200 indicated horse-power and the first one was erected at their works about eighteen months ago. Boilers of this construction were originally bolted up in slabs 25ft. long, where considerable power was required; but in such cases it is now preferred to employ two or three slabs, one behind the other, as shown in Fig. 1, Plate II, each slab being about 9 ft. long. When this arrangement was first employed, the steam pipes, connecting the front and back slabs, were made of cast iron, and of a form which did not allow of the unrestricted expansion of the slabs. Some of these pipes cracked; but they are now made of wrought iron, and of a form to yield readily to a moderate strain.

Mr. Harrison had, from the first, counted upon entire freedom from corrosion of the spheres, and the experience thus far has borne out this anticipation. Cast iron, as is well known, endures much better than wrought iron under the action of flame, water, and other corrosive influences. It need hardly be said that plate iron would, if employed for gas retorts, be immediately burnt through, yet until the introduction of clay retorts, cast iron answered very well. The pipes for

heating the blast of blast furnaces were originally made by Mr. Neilson of plate iron, but, although the blast was then heated to but 350 degs. it became immediately necessary to resort to cast iron heating pipes. The superior durability of cast iron forge tuyeres, especially where made hallow and lined with water, is well known. Mr. Jaffrey, the engineer to Messrs. Thomas Richardson and Sons, of Hartlepool, has employed cast iron superheaters with much success, and he has informed the author that four superheaters upon his plans, fitted on board the steam colliers Berwick, Killingworth, Wearmouth, and Earl of Elgin, showed no sign of corrosion, when examined in October last after four years of almost constant service. Mr. Jaffrey's assistant reported to him that the superheaters "looked almost as well as on the day they were put in; there was not the slightest sign of external corrosion, and the pipes when cleaned look like new castings. The cast iron connexions of the Earl of Elgin are just the same; the heat does not seem to have taken any effect on them." Mr. Jaffrey adds, "I am quite satisfied in my own mind as to the value of cast iron where a strong heat is applied, as these and kindred instances establish." In the case of the Harrison boiler many castings have been purposely removed and examined, but their weight is the same as when they went in, and the joints show no degradation of their original surface.

The point, in connexion with the boiler now described, which caused most apprehension in the first instance, was that of maintaining a clean surface within the spheres. The cast iron boiler may be said to belong to the family of water tube boilers or those having small water cells. The water tube boiler is at least sixty years old, for Arthur Woolf fitted one in Meux's brewery, in London, in the year 1804. In the same year John C. Stevens, of New York, worked a small screw steamboat on the river Hudson, the engine of which vessel was made by Boulton and Watt, while the boiler had eighty-one water tubes 1in. in diameter and 2ft. long. From the first, however, water tube boilers have generally failed on account of defective circulation, and from the difficulty of keeping the tubes free from internal deposit. Many attempts have been made to remove this difficulty. Mr. William Henry James long ago proposed to employ circulating pumps, in addition to the ordinary feed pump, to maintain a constant circulation of water through the tubes. The boilers of the first American steam fire engines were thus constructed, and Mr. Spencer, and Mr. Russell some time since, gave descriptions of such a boiler to this Institution. Other forms of water tube boilers have been made with different means for promoting a circulation of the water, but in all cases the whole of the inorganic matter contained in the feed water must remain in the boiler, unless it be blown out while working; and in case of some salts held in solution by ordinary boiler waters, these are inevitably and almost irremovably deposited upon some part of the internal surfaces. The Harrison boiler forms no exception to the general experience in this respect. The water with which Messrs. Hetheringtons', and indeed most boilers in Manchester, are fed, is such as to form a hard scale, $\frac{1}{4}$in. thick, after a few weeks time. A tool had been contrived with

steel scrapers, so hinged, that it might be entered through any of the openings in the cast iron boiler, and be then forced out to the internal circumference of the spheres. By then working this tool within the spheres the scale would be removed, so that it could afterwards be blown out. Unexpectedly, however, no occasion has arisen for the use of this tool. It was found that the supply of steam continued good without it, and that none of the spheres were overheated or leaking. The boiler was regularly blown out at the end of every week. After ten months' work it was desired to increase the boiler power of Messrs. Hetheringtons', and as the large cast iron boiler then in use there was formed of units having only two spheres each, it was thought best to replace it with a new boiler having four spheres in each unit, with the exception of those employed for breaking joint, which had two spheres as before. On taking down the old boiler little or no scale was found in any of the spheres, some of which, in the same condition as when taken down, are now exhibited to the meeting. One taken from Messrs. Hetheringtons' twelve horse boiler was broken by the author, and having been marked by him is also exhibited. It was purposely taken from near the bottom of the boiler, and it had worked constantly for eight months without any examination. It will be seen that the broken pieces, which are in the same condition as when the author took out and broke the casting, contain no scale. In taking down the old boiler, however, a lump rolled out of one of the spheres, and this the only one of the kind found, is also exhibited, although it has been accidentally broken in two. It consists of scales, seldom larger or thicker than a sixpence, loosely cohering together by a clayey deposit from the water. In the mass it is very friable, but the fragments of scale are, of themselves, of the same obdurate sulphate of lime as that which hardens in nearly all other boilers in the same district. Yet they have in every case separated from the iron before attaining a thickness greater than one-sixteenth of an inch. It cannot be because the boiler is of cast iron that it so readily sheds its scale; Trevithick's boilers, and the cast iron boilers long made by Mr. Hall, of Dartford, and known as "elephant boilers" enjoyed no immunity in this respect, when compared with wrought iron boilers fed with the same kind of water. In the Lancashire district, too, the cast iron pipes of Messrs. Green's "Patent Economizer," are known to be subject to choking with scale in the same manner as if they were made of wrought iron. In some cases they become completely choked, and can only be cleared by a boring tool. The fact that the spheres of the Harrison boiler shed their scale is not referable, therefore, to the material of which they are made. It might, perhaps, be argued that the water is occasionally driven from the internal surfaces, and that the consequent expansion of the spheres, and their subsequent contraction on the return of the water, would account for the loosening and breaking of the scale. But the spheres show no evidence, as in this case they might be expected to do, of the irregular action of the fire, and, too, those of the spheres which are placed far behind, where the action of the heat is moderated, are equally free from scale. It appears to be


THE HARRISON STEAM BOILER .
Water Level

more probable that, as the spheres expand at all parts, and, in cooling, contract equally at the same parts, the scale is detached and crushed in this process of contraction. If this conjecture be correct, the unexpected separation of the scale may be attributed to the form and dimensions of the spheres themselves. Whatever explanation may be offered it is certain that, with foul water, and with such as gives much trouble with other boilers, the scale breaks freely off, and into small pieces, in the cast iron boilers now described. This is, perhaps, one of its most valuable properties; but it was quite unforseen. It would not be prudent to anticipate the result in the case of the application of the Harrison boiler to marine purposes; but with all the land boilers upon the plan now described, it has been found that, with a blowing off once a-week, they may be worked indefinitely without any formation of scale. The description already given will show how readily the cast iron boiler may be laid open for examination, and it was recently thought expedient to open the large boiler at Messrs. Hetheringtons' for this purpose. A small quantity of loose and broken scale—perhaps a tablespoon full—was found in each of the spheres examined, but their internal surfaces, so far as they could be seen, were entirely clear.

The evaporative efficiency of the cast iron boiler depends, as in the case of all other boilers, upon the amount of heating surface exposed in proportion to the consumption of a given weight of fuel in a given time. The boiler, by which Messrs. Hetheringtons' works are now driven, supplies an amount of steam which a single Lancashire boiler 7ft. in dameter, 30ft. long, and weighing 14 tons, was found inadequate to produce. Both the original and the present boiler are in connexion with a chimney 165ft. high, and which affords an excellent draft. The Lancashire boiler had two flues 2½ft. each in diameter, and enlarged at the fire-place to 3ft. The area of the fire bars was 36 square feet, and the total run of the heat was 90ft. in length. The cast iron boiler now in use has about 1800 spheres, weighing 18 tons, and presenting about 1600 square feet of surface in the water spheres, and about 700 square feet in the steam spheres. The area of fire-grate is 33 square feet. The usual quantity of water carried is 147 cubic feet, or rather more than 4 tons, the quantity usually carried in the former Lancashire boiler being nearly 20 tons. The external dimensions of the present boiler are considerably less than those of the Lancashire boiler formerly employed. Rather more than 3 cwt. of coal are now required in raising 50 lbs. of steam from cold water, and the time occupied is about half an hour. In order to ascertain the exact evaporative efficiency of the boiler, it would be necessary to begin the observations when it was in full work, and to continue them uninterruptedly for a considerable time. As the boilers are now worked, the fires are lighted on Monday morning and let down on Saturday afternoon, but they are banked every day at breakfast time, at noon, and at night. The mass of brick-work, which is thus alternately heated and cooled with the boiler, is very great, and the heat which enters it, and which on stopping, is for the most part wasted, is correspondingly large. Except at the beginning of the week, the temperature of the water in

the boiler on starting in the morning is at least 212 degs., while the feed water from the hot-well is usually between 90 degs. and 100 degs. On the 13th, 15th, and 16th of February last, the author made a series of careful observations upon the working of Messrs. Hetheringtons' boiler, more especially to ascertain its evaporative efficiency. The coal, of good quality, and from the Oldham pits, was carefully weighed and the feed water was made to pass through one of Worthington's water meters on its way to the boiler. The indications of the meter were ascertained to be accurate, one of the best tests being its registration of 147¾ cubic feet, in filling the boiler to a point known to exactly correspond with that quantity. Between 5h. 40min. in the morning, and 12h. 55min. p.m., with an interval for breakfast, the whole consumption of coal was 38 cwt., and of water 442·7 cubic feet. If the quantity of water evaporated were to be divided by the gross consumption of coal the quotient would be 6½ lbs.of water only evaporated per pound of coal; but in heating the boiler and its contents to the working point, and in the loss at breakfast time, the consumption of coal was such that 24 cwt. were burnt while evaporating the first 200 cubic feet of water, while the remaining 14 cwt. held out for the time during which 242·7 cubic feet of water were evaporated. Allowing for the lowering of the fires at the hour for stopping work, the quantity of coal actually expended in evaporating the 242·7 cubic feet of water may be taken at 16 cwt., corresponding to an evaporation of 8·43 lbs. of water per pound of coal. Towards the end of the trial, in a period of 1h. 40min., 8 cwt. of coal were burnt and 142·7 cubic feet of water were evaporated. But as this would correspond to an evaporation of 9·91 lbs. of water per pound of coal, it is probable that a portion of the water was vaporized at the expense of the heat already in the water, and in the boiler and its brick-work setting. That this was the case is proved by the fact that in the last 50 minutes of the trial only 2 cwt. of coal were burnt, while 80 cubic feet of water were evaporated, a proportion which were the total evaporation due to the quantity of coal actually burnt within the same period of time would have corresponded to the evaporation of nearly 22½ lbs. of water per pound of coal, which, it is needless to say, would have been impossible. In making these observations there was always the uncertainty attending the quantity of coal assignable to heating the boiler and its contents and setting, up to the working temperature, and that due to evaporation alone.

On the 15th of February, starting with water at about 45 degs. temperature, 5 cwt. of coal were consumed in raising steam to the working pressure, the time occupied being half an hour. Including the coal burnt in raising steam, 2 tons 18 cwt. were consumed during the day, and 657¼ cubic feet of water were evaporated, corresponding to 6·3 lbs. of water per pound of coal. But as a greater quantity of heat was manifestly left in the boiler, and brick-work on stopping than when work was commenced in the morning, and as there was a waste of heat during the breakfast and dinner hours, not more than 2½ tons of coal, at most, can be fairly charged to the water evaporated. It

was the opinion of those who witnessed these experiments that even this was too large an allowance of coal. It corresponds to 7·3 lbs. of water per pound of coal. The evaporation, from noon until the hour of stopping at night, averaged 7·56 lbs. of water per pound of coal; while, for the last four hours of the experiment, the apparent rate of evaporation was 8·71 lbs. On February 16th, steam having been kept in the boiler over night, the consumption of coal from 6 a.m. till 2½ p.m. was 2 tons 6 cwt., which included the loss during the breakfast and dinner hours, and the evaporation was 519 cubic feet, corresponding to 6·3 lbs. of water per pound of coal.

In a whole week, of 57½ hours, an average of 77 cubic feet was evaporated per hour, the maximum evaporation being about 82 cubic feet per hour. The average consumption of coal was 6 cwt. 1 qr. per hour, corresponding to 6·85 lbs. of water per pound of coal, but allowing for the sources of loss already pointed out, nearly 8 lbs. may be taken as the effective rate of evaporation. The temperature of the escaping gases, as indicated by Gauntlett's pyrometer, was about 600 degs. on the average, the steam of 50 lbs. pressure, showing its normal temperature of about 300 degs., by a thermometer inserted for the purpose. The average rate of combustion was 21 lbs. of coal per square foot of fire-bar per hour. When the fires were not driven so hard the rate of evaporation per pound of coal was increased, and the temperature of the escaping products fell to 525 degs. The flame penetrated freely between the spheres for a distance of eight or ten feet from the bridge, and three-fourths of the whole evaporation effected probably took place within this distance. The spheres in the slabs at the back of the boiler were generally covered with a light coating of soot, which was swept off every week, all the spheres being within easy reach for this purpose. Soot never formed, however, upon the spheres near the fire. The water level was very steadily maintained within a small range of oscillation. As feed water entered the boiler at the back, there could be no doubt, when it stood at its proper height in the glass gauge in front, that its level was properly maintained throughout the whole length of the boiler. A small cock, tapped into one of the steam spheres a short distance above the water level, showed damp steam, indicating a vigorous circulation of the water below, but, in the engine room, the steam blown from the cylinder cocks was quite dry, showing the value of the superheating surface formed by the upper or steam spheres of the boiler. In a recent instance an inclination of 45 degs. has been adopted for setting the slabs, and it is believed that this permits of a still better circulation of the water, or, rather, an easier disengagement of the steam from the water.

A lengthy paper might be prepared upon the mode of making the castings of the boiler and of forming the joints. The system pursued in the foundry is such that, with green sand cores, the units are moulded with about the rapidity and economy of plate moulding. The cores are well hammered on the eight prints upon which they rest in the sand, and there is no chance of their being displaced in pouring or otherwise, except by a force sufficient to break them in pieces. The two halves of the moulding boxes are drawn apart in such a manner

as to prevent any chance of breaking down the sand, and a little or no sleeking is required. Each casting is critically inspected, but, as the moulders are not paid for imperfect castings, very few are made. The joints are faced up by special and powerful machinery. The spheres are 9 ins. from centre to centre, and these machines not only preserve that distance exactly between the openings on the same side of each unit, but they face the joints so that those on opposite sides of the unit shall be precisely 9 ins. apart. Each machine has two headstocks, with eight spindles and rose-cutters in each headstock, and the castings being immovable and held in a clamp, are faced in pairs, a roughing cut being taken on the eight joints of one casting while a finishing cut is going on upon the eight joints of the other. Twenty-five tons of castings pass under the roughing cutters before they require grinding, and 100 tons of units are completely faced before the finishing cutters require to be re-ground. By a special adjustment, the finishing cutters may be set up in their spindles by the one-thousandth part of an inch, when, from the dulling of the cutting edges, the distance between the opposite joints of the units are found to exceed the length of the standard gauge of that quantity. Of an infinite number of castings any two will exactly correspond. When placed together the bearing surface at each joint is $\frac{3}{16}$in. wide all round, and it is finished with a truth not inferior to that of a good slide valve face. If a sheet of oiled paper be placed upon a smooth board, and two units be placed upon it, one above the other, they may be filled with water, without any perceptible leakage at the joints even after the lapse of a week.

In conclusion it is believed that the boiler now described possesses several important advantages. It is believed to be absolutely secure from explosion, and, so far as experience has gone, free from any liability to choke with scale. It is durable, easily taken apart and put together, and it may be erected in almost any form, adapted to that of the space in which it may be necessary to place it. The parts are very portable, and they may be taken through any opening where a boy can pass. Any part of a boiler upon this construction may be readily renewed if necessary, and an existing boiler may be at any time readily enlarged, and to an indefinite extent, by adding to the number of slabs either at the sides or at the back. The economy of the boiler in first cost is obvious, and with proper proportions between the fire-grate and heating surfaces, as high an evaporative efficiency may be had as with most other forms of boilers. The quantity of water carried being comparatively small, steam may be raised with a small quantity of fuel and in a short space of time. Water may be left standing in the boiler for almost any length of time without injury. Every part of the boiler is at all times under ready observation, without disturbing the connexions, and the spheres may be easily swept on their outsides. The setting of the boiler is such also that the steam may be dried to any extent desired in the spheres themselves, without any other provision for superheating. It is thought that this boiler especially meets the increasing tendency to use high pressure steam, and that the description now given will, therefore, prove interesting to the members of this Institution.

Proceedings of the Association for the Prevention of Steam Boiler Explosions, Manchester.

[Report of Chief Engineer, November 24, 1863.]

From the London Mechanics' Magazine, Nov., 1863.

During the past month there have been examined 238 engines and 381 boilers. Of the latter, 17 have been examined specially, 9 internally, 55 thoroughly, and 300 externally, in addition to which 1 of these boilers has been tested by hydraulic pressure. The following defects have been found in the boilers examined:—Fracture 10 (1 dangerous); corrosion, 25 (5 dangerous); safety-valves out of order, 1; water-gauges ditto, 30 (3 dangerous); pressure-gauges ditto, 5; feed apparatus ditto, 2; blow-out apparatus ditto, 15 (1 dangerous); fusible plugs ditto, 3; furnaces out of shape, 12 (3 dangerous); over-pressure 3 (1 dangerous); Total 106 (14 dangerous). Boilers without glass water-gauges 3; without pressure-gauges, 45; without blow-out apparatus, 48; without back-pressure valves, 72.

An illustration has lately been met with of the importance of removing portions of mid-feather walls, in order to give an opportunity of examining the plates. On this being done at the instance of this Association, in the case of a boiler lately put under its care, the bottom, although presumed by its owner and engineer to be perfectly sound, was found to be nearly eaten through by corrosion, and on the very point of rupture, as in the case of No. 39 Explosion, the details of which are given below.

Instances continue to be met with of serious corrosion, arising from the leakage of bolted joints concealed under brickwork. It cannot be too often repeated that all connexions to boilers should be made by means of fitting blocks riveted to the shell, excepting only the attachments to the front end plate, where they are not absolutely necessary, since the plate being flat the joints are more easily made, while at the same time, from their position, leakage, should it occur, is at once apparent. The front end plate should be left completely open, and not, as is too frequently the case, covered in with a wall of brickwork, since leakage—so prone to occur in the neighborhood of the furnace mouths—is found to go on behind the brickwork undetected. A case of this sort has just been met with, where a plate was completely eaten through before the corrosion was known.

Explosions.—No. 31 Explosion occurred at a distance of nearly three hundred miles, and as full details could not then be obtained, the fact of its occurrence was merely entered at the time in the tabular statement. The boiler was not under the inspection of this Association, and it has since been ascertained that it was of plain Cornish construction, having a single flue parallel throughout; its length being 25 feet 3 inches, its diameter in the shell 5 feet 7 inches, and in the flue 3 feet 5 inches, while the thickness of the plates was three-eighths of an inch, and the pressure to which the safety-valves were loaded, 40 lbs. Such a flue, on account of its large diameter, was unsafe from the day on which the boiler was made, though it might easily have

been made secure by adopting any of the well-known plans of strengthening flues, among which may be mentioned, hoops, whether of T-iron, angle iron, or bridge rail section, as well as flanged seams.

Six explosions have occurred during the past month, resulting in the death of eleven persons, and serious injury to eighteen others. Not one of the boilers in question was under the inspection of this Association. One of these exploded boilers, No. 39, has been personally examined, while this was prevented in other cases by distance, some of the explosions occurring upwards of two hundred miles from Manchester. It is expected, however, that detailed particulars of all of them will be obtained, while I am already indebted for a minute report on Explosion No. 38, to the kindness of an engineer residing in its locality, and who made an examination shortly after the occurrence.

No. 38 Explosion, from which one man was killed, occurred to a boiler not under the inspection of this Association, and which was in use at an iron works.

The boiler was of a plain cylindrical egg-ended shape, externally-fired, and connected by its steam pipe to two others of different construction; all three collectively working an engine and forge hammer in the rolling mill. The ordinary working pressure of the boiler was 40 lbs., its length 35 ft., and its diameter 6 ft. 5 ins., while the plates were of the most unusual and unnecessary thickness, of from nine-sixteenths to five-eighths of an inch.

It is more difficult to make good work in a boiler with such thick plates, and it is reported that the joints in the present instance were imperfectly closed—that there had been unfair use of the drift, than which few things are more prejudicial to the strength of the boiler—that but few of the rivets were properly laid up, while, in addition, the overlap of the plates at the seams of rivets were unusually wide, and, in short, that the work was altogether most clumsy and inferior. Added to this, the boiler had been repaired over the fire more than once, with plates $\frac{1}{8}$ of an inch thinner than the rest, while longitudinal seams of rivets, six feet long, were allowed to fall within the furnace, their original length having been increased by the repairs.

The boiler had been leaking at the seams in the furnace for three weeks previous to the explosion; and in order to stop this the fireman had been in the habit of putting a bucket-full of sharps as well as a bucket-full of horse manure into the boiler once a week.

The state of the boiler after the explosion afforded no indications either of overheating from shortness of water or of corrosive action, while there appeared to have been little or no incrustation; but it was found that the shell had rent at one of the longitudinal seams over the fire, just where the thick old plates had been patched with the comparatively thin new ones. The rent extended throughout the whole length of the seam, and then ran into the transverse ones which crossed it at both ends, completely severing from the remainder of the shell the dome or egg-end. The latter was blown to a considerable distance, while the former, though lifted off its seat, was only thrown a few feet from it.

The cause of the explosion was made a subject of scientific investigation at the order of the coroner, and the view given in the report thereon by the engineer engaged, may be briefly stated as follows:—

The explosion was considered to be due to excessive pressure of steam, a pressure greater than that at which the boiler was ordinarily worked, and which it was thought might have arisen in the following way:—The explosion occurred shortly before four o'clock in the afternoon, the boiler having been cleaned out the same morning, while the other two to which it was connected were working alongside meantime. In order to clean this boiler out while the others connected to it had their steam up, it was necessary that the junction valve should be closed, and if this valve had not been re-opened, as it ought to have been, as soon as the steam was up—then in the event of the only safety valve with which this boiler was fitted, either sticking fast in its seat or being tampered with—the steam would be bottled up, and the pressure continue to rise, without giving any sign until actual explosion resulted, since there was no steam-gauge upon the boiler.

One or the other of these two conditions it was concluded had occurred viz:—either that the safety-valve had stuck fast in its seat, or had been intentionally tampered with, at the same time that the boiler was isolated from the other two by the junction valve being shut down.

The supposition of the junction valve having been left closed, was, it was thought, strengthened by the fact that the steam had been so low a few minutes previous to the explosion, that both engines had to be stopped, so that had the boiler in question been then in connexion with the others, it was argued that the rupture must have taken place when the pressure was lower than usual, which was not thought likely. That the safety-valve had stuck fast in its seat, was considered most improbable, while the supposition of its having been intentionally tampered with derives support from the reckless character of the fireman, who, shortly after the explosion had occurred, was known, while tending the boiler alongside the exploded one, to have gagged his alarm whistle on it signalling shortness of water; in consequence of which a number of workmen engaged near the boiler deserted their post stating that they considered their lives in danger.

The jury dissented from these views, and brought in a verdict of accidental death, adding—"That in their opinion the boiler did not explode from excess of steam, but from a combination of gases occasioned by the lifting of the junction-valve when there was not a sufficient pressure of steam. The consequence of the junction-valve being opened under these circumstances, would be, that the steam would rush into the boiler from the adjoining ones, and, by generating gases within it, blow it up.

The opinion of the jury can scarcely be regarded as otherwise than hypothetical, and as being entirely unsupported by experience.

The view that the boiler exploded from excessive and unusual pressure, consequent upon the safety-valve and junction-valve being both closed at the same time, is thought to be an unnecessary supposition,

considering the workmanship of the boiler, as well as its condition and the treatment it received, all of which have been previously described. A boiler, roughly made as this was, of plates of excessive and varying thickness, having an unusually wide overlap, and being in a leaking condition, with its seams choked up with bran and horse dung, such a boiler when exposed to the action of an external fire would be utterly untrustworthy, and the mere pressure of steam by no means the only element of weakness. Such thick plates, unless most kindly laid together, would be fighting one against another, especially under the action of the fire, when unequal expansion, aggravated by the varying thickness of the metal, would be sure to ensue. Moreover, had the pressure in the boiler at the time of explosion been higher than that at which it ordinarily worked, or indeed equal to it, viz: 40 lbs., the main portion of the shell would never have remained so near to its original seating as it did, and thus the position of the fragments can only be accounted for by the supposition that the steam was low at the time of explosion, which is borne out by the fact that there was not power enough to drive the engines, and they were stopped in consequence.

This explosion, therefore, can only be regarded as an additional illustration of the dangerous character of the externally-fired boiler, especially when improperly repaired and carelessly attended to. The constant allusion to such cases may be tedious; but the subject is only recurred to on the repetition of explosion; and it is trusted that the persevering statement of these facts will assist in removing from general use so dangerous a class of boiler as those externally-fired have proved themselves to be.

No. 39 Explosion, which was attended with the death of one person and injury to four others, occurred to a boiler working at a cotton mill, and not under the inspection of this Association.

The boiler which was fifteen years old, was of plain double-flued construction, internally-fired, and of the class termed Lancashire, its length being 32 feet, its diameter 8 feet in the shell, and 3 feet in the flues. It worked alongside of another boiler very similar to itself, and to which it was connected.

The boiler had rent at the bottom of the shell, immediately over the mid-feather wall on which it had rested. This rent, which may be termed the primary one, extending longitudinally for about two rings of plates, and then assumed a transverse direction, running completely round the boiler and severing an entire, though rather irregularly-shaped, belt from the shell. The front end plate was separated from the other part of the boiler, while the furnace tubes, which appeared perfectly sound remained attached to the rest of the shell, which had been thrown out of its original seat and turned bottom upwards. The longitudinal stays for stiffening the end plates, though massive, were curled up into a scroll, and the transverse ones, which should never be introduced in a cylindrical boiler, proved, as might have been expected of no assistance in strengthening the shell.

The damage to the surrounding property was serious, a considerable

portion of the mill being unroofed, and one of the side-walls blown down, while the boiler-house was reduced to a heap of ruins.

As to the cause of the explosion there can be no question; there was no evidence of shortness of water, the furnace crowns being uninjured; but on examining the edges of the plates at the primary rent, which had occurred over the mid-feather wall, their thickness was found to have been so reduced by external corrosion as not to exceed that of a half-penny piece.

In the scientific evidence given at the inquest, the plan of setting boilers upon mid-feather walls was strongly condemned, and the corrosion so frequently induced, and at the same time treacherously concealed by them, clearly pointed out. Of the truth of this there can be no question; and it is difficult to say anything more upon the danger of these mid-feathers than has already been said in previous reports while the occurrence of the explosion in the present instance affords an additional illustration of the correctness of the views so frequently expressed.

The jury considered that this explosion would have been prevented by due precaution on the part of the owner, and therefore brought him in guilty of manslaughter.

The Production of Sulphur in Italy. By M. P. Bianchi.

From the London Chemical News, No. 225.

The sulphur at present produced in Italy amounts to no less than 300,000 tons a year, the value of which in the rough state is 30,000,000 francs. This yield, which has increased ten-fold since 1830, is furnished in great part by Sicily. The quantity produced in Romagna, formerly but small, has since increased to 8000 tons per annum.

During the last ten years great improvements have been introduced in the method of extracting sulphur from its calcareous gangue. It is always obtained by liquefaction by burning a portion of the ore: but this operation formerly performed in small, open, cylindrical furnaces (*calcarelle*) is now effected by simply heaping the stones and covering them with earth as in charcoal burning. These heaps, called *calcaroni*, are of considerable size, often four hundred times larger than the old furnaces. This new mode of operating has the advantage of diminishing the losses occasioned by the production of sulphurous acid, so that the yield of sulphur is increased by one-fifth; besides sulphur can be burnt in this way near houses and gardens, which, with the old method was out of the question. Formerly it was burnt only at certain periods of the year, now it can be burnt at any time, so that it is no longer necessary to accumulate large quantities of ore. Finally, the operation, which used to be very frequently fatal to the workmen, is now almost harmless.

Sulphur of Romagna and the Marshes.—At Bologna there is a society called "Société des Mines de Soufre des Romagnes," which possesses eight mines, five in the province of Forli (Romagna) called Firmignano, Luzzena, Fosco, Busea, and Montemamro. The other

three, forming part of the province of Urbino and Pesaro, are those of Perticara, Marazzana, and Montecchio.

Most of the sulphur from these workings is refined at Rimini, whence it is carried to the places where it is most in demand, such as Venice, Trieste, Ancona, Lombardy, Tuscany, &c.

This refined sulphur is chiefly used for making sulphuric acid, and lately for the treatment of the vine. Its price, which varies considerably, is in cakes, from 213fr. 10c. per English ton of 1·015 killogrammes, and in sticks from 254fr. 35c., put on board vessels in the ports of Rimini and Cesenatico, and delivered at the stations of Rimini and Cesana.

Sulphur from the Neapolitan Provinces.—Sulphur is found here in several places, but in small quantities. It is thus found in the volcanic region of Solfatares, where it exists mixed with clay and other matters from which it is separated by sublimation, but the yield is insignificant. Small deposits of it are found scattered in the district of Majella, one of which is worked at Santa-Liberata. It has recently been announced that there has been discovered at Civita-Nova a bearing of calcaire impregnated with sulphur, but nothing has been said as to its richness and extent. No more is known of another bearing at Santa-Regina, two miles east of Ariano.

Sulphur of Sicily.—Sulphur exists here in a gypseous bed, layers of which extend over a small portion of the island, from Mount Etna to near Trapani. This formation belongs to a geological epoch which has not yet been positively determined. Here, as in Romagna, it contains, besides gypsum, calcaires and clays, more or less marl. In the first case, the sulphur exists in a state of mixture, sometimes uniformly, sometimes irregularly, sometimes in small parallel veins and more rarely in the form of crystals; in the latter case it is not unusual to find it associated with *cœlestine*, or sulphate of strontium. In clay, on the contrary, it is found in globular masses which is also the case in similar bearings in Continental Italy.

There are about fifty mines in Sicily, employing 20,000 workmen. The most productive mines are in the provinces of Caltanisetta and Girgenti; ranging next in importance, are those of the provinces of Catana, Palermo and Trapani. The sulphur is extracted in the manner above described by means of *calcaroni;* the loss during the operation amounts to one-third of the ore. Most of the sulphur is exported in the crude state, but little being refined in the island. In this state it is divided into three qualities, the second and third being subdivided into three other qualities. The yield in 1861 was estimated at about 240,000 tons of commercial sulphur, of which about half was produced by the province of Caltanisetta, a third by Girgenti, 25,000 by Catana, and 20,000 by Palermo; the quantity produced by the province of Trapani is very inconsiderable. Most of the sulphur is exported to France and England.

The price of this product has risen during the last few years; in 1860 it sold in the crude for, from 15 to 20 frs. the ton.—*Moniteur Scientifique*, v. 799. 63.

Apparatus for the Prevention of Steam Boiler Explosions and Railway Accidents.

[From the Proceedings of the London Association of Foremen Engineers.]

From the Lond. Mechanics' Magazine, Sept., 1863.

The Chairman called upon Mr. Gettliffe to read his promised paper on "an Apparatus for the prevention of Steam Boiler Explosions and Railway Accidents." That gentleman, after some preliminary observations, proceeded to say that the apparatus in question was the invention of M. Auguste Achard, C. E., of Paris, and that it was known in France under the title of the "Embrayage Electrique." It was calculated to maintain a constant level in steam boilers by automatic means, and without the assistance or supervision of the engine-man. This regulator, as it might be termed, consisted of a ratchet wheel of peculiar construction, and which was keyed, upon a spindle turning freely in its bearings. Right and left of the wheel were mounted, loosely on the spindle, two wrought iron levers of about 20 ins. each in length, and connected together by cross-pieces. A two-armed "click" supported by the levers, turned freely round an axis. The double click acted freely upon the ratchet wheel which was furnished with two sets of teeth, turned in opposite directions to each other, and separated by a blank space. The click was fitted with a tail-piece in the form of a fork, the two prongs of which were braced together by a cross rod. In the fork was mounted an "armature," which was provided with an opening through which passed the cross piece. The armature was made of brass, and to it was attached a plate of soft iron fitted in so as to be flush with the surface of the armature. Opposite to this latter was placed a horizontal electro-magnet, the poles of which abutted against the armature in such a way as that it (the armature) could only slide against the poles without coming into immediate contact therewith. The part played by the armature was merely to act as a weight on the levers supporting the fork; for it would be understood that when the electric current was in circulation, the armature would be suspended by its adherence to the electro-magnet, and thus relieve the fork of its weight. The suspension of the current, on the contrary, would cause it to drop on the cross-piece connecting the levers, and thus alter the gravity of the fork. It was these alternations of the weight on the tail-piece of the levers which caused the fork to act upon the upper or lower set of teeth on the ratchet wheel; or in other words, to open or shut the feed-cock of the boiler. It was necessary that the fork should have continual motion—a kind of pump-handle movement indeed—which could be effected by a simple contrivance (a small eccentric, for instance, attached to a running shaft on the general machinery). The effect would be that the compound ratchet wheel would be acted upon and moved in one direction when the boiler required feeding, and in the other when it had been fed sufficiently. If all were going on well, the click would be simply moved over the blank portion of the wheel, and communicate no motion whatever to it. Proceeding now to the general action of the contrivance, the reader proceeded to state that

when the current was broken off from the electro-magnet, the weight of the armature operating upon the cross-piece would press down the tail-piece of the levers carrying the click, which latter would rise and act with its lower arm upon the ratchet wheel. The consequence would be, that the wheel would turn from left to right to the extent of one tooth, or about half an inch, at each oscillation of the levers, until the blank space presented itself and stopped further movement. This would be at a point when the wheel had made one-fourth of a revolution. On the other hand, when the current was in circulation, the armature in sliding against the poles of the electro-magnet, would bring the plate of soft iron into contact with the poles, which would then hold it firmly, and prevent the armature descending with the click during the downward oscillation of the levers. The tail-piece would thus be relieved, and not have to support any weight while the levers rocked in the opposite direction. It would follow that the upper arm would then act upon the wheel and cause it to turn the reverse way, *i.e.*, from right to left. It would thus become evident that the two-armed click would act on the ratchet wheel, and cause it to move in opposite directions, whether the electric current were traversing the electro-magnet or not. "Now," said the reader, "the characteristic feature of the electric regulating apparatus is arrived at." The rising or falling of the float in the boilers of stationary or land engines controls the electric current, and causes it to circulate or be interrupted at the proper times. This result is obtained directly by the wires which proceed from the pile or battery being made to pass first to the float instead of being connected immediately to the electro-magnet. The float itself was connected by a rod with an index, on the lever of which was mounted a piece of wood faced on one side with a brass plate. On another piece of wood, in the form of a rocking lever, and moving on an axis, was a second plate of brass. The electric wire from one of the poles of the battery was fixed to the first named plate, and the other end of the wire, after traversing the electro-magnet, was attached to the other pole of the battery. In order that the current might circulate, it was indispensable that both plates should meet, and from the peculiar arrangement of the two metallic plates, they would always be in contact when the index was at zero (the normal feeding point) or above it, but the contact ceased as soon as the index fell below zero. Let it be supposed that the feed-cock of the force-pump, or other contrivance for supplying water to the boiler, was connected to the spindle of the ratchet wheel: it would follow that the cock must partake of the movement of the wheel, and that it will make a quarter of a turn in one direction when the electric current circulated, and a quarter of a turn in the other when the current was interrupted; thus the automaton regulator, which was sensitive to the smallest alteration in the water level of the boiler, was perpetually and inevitably maintaining it at a constant height, and thus one great scource of danger was obviated. As an extra security, however, against accident by explosion, a minor contrivance was affixed to the same apparatus, and which owed its action to similar principles. On the side of one of

the levers was fastened a cap with a gudgeon in its centre. An armature resembling that already described was carried by this cap and rested on the gudgeon. In connexion with the second armature was placed an electro-magnet, against which it was made to slide and press constantly upon the poles. It was still the index of the water gauge, which induced the circulation or effected the interruption of the electric current; and the same electric pile or battery, composed of a single element, or Daniel's pair, sufficed to put in motion the two electro-magnets. The electric wire which proceeded from one of the poles of the battery, and was affixed to the brass plate on the lever of the index, served for the two electro-magnets also. The returning wire corresponding with that about to be described, however, was fixed to a third brass plate, and, after traversing the electro-magnet was attached to the second pole of the battery. The last mentioned plate was arranged in such a manner as to establish a metallic contact, which permitted the electric current to pass, notwithstanding the variation in the level of the water to the extent of an inch above or below its proper line. If the variation exceeded these limits, the current would be forcibly broken. When the electric current was in circulation—that is to say, when the lever was between the limits of variation named—the armature would be suspended by the adhesion of the second electro-magnet; but if the level rose or fell beyond those points the armature, from the current being broken, must fall. In either case, a small tappet fixed to the armature below the gudgeon touches an alarm lever and thus rings a bell. This arrangement was also serviceable in other respects. The alarm bell rings when the feed pump is out of order; when the electric pile ceases to act; if the stoker neglects the fire; or if steam is generated too rapidly. The reader proceeded to point out the application of the "Embrayage Electrique" to the prevention of railway accidents by connecting it with brakes upon the wheels of the engines and carriages, and certainly gave some very practical illustrations of its value and efficacy in this respect. In France it is extensively used, and testimonials in its favor from many eminent scientific men were submitted to the Associated Foremen Engineers on Saturday night. Mr. Gettliffe, moreover, exhibited the apparatus itself to his audience, and thus gave them a further opportunity of judging of its characteristics.

On the conclusion of the paper, a short discussion arose; and in this Messrs. M. Jones, Ives, Briggs, and Bragg took part. In reply to questions put by these gentlemen, the reader stated that at the works of Mr. Carter, engineer, &c., Grove, Southwark, an apparatus of the kind he had attempted to describe might be seen in daily action, as also at Messrs. Simpson's, in Little Britain City. The office of M. Achard was at 1 Little Carter-lane, St. Paul's.

The Chairman then proposed a vote of thanks to Mr. Gettliffe for the able way in which he had explained an ingenious apparatus of great interest to the members of the Society of Foremen Engineers. He had, from what he had heard and seen on that evening, formed a good opinion of the contrivance, and he should take an early opportunity

of witnessing its action. The time was approaching when Electricity would become a universal handmaiden to applied science, and mechanical men would do well to study closely its phenomena. M. Achard had, in the production of his "Embrayage Electrique"—in substitution for the title of which an English one must be found as expressive—demonstrated his great talent, and in Mr. Gettliffe he had found an excellent expositor.—The vote of thanks having passed, the meeting shortly after separated.

A Critical and Historical Review of Locomotive Engineering.

By J. J. BIRCKEL.

From the London Artizan, Jan., 1864.

In our paper of January, 1863, we have shown that the total quantity of heat contained in a given weight of steam remains practically constant for all pressures, and we have therefrom drawn the conclusion that steam engines become more economical gradually as the working pressure of the steam increased, without, however, giving any numerical value to the rate of increase of economy with pressure. As this subject cannot be too forcibly impressed upon the minds of our readers, having been enabled to supply this interesting item of information by means of the data on the density of steam furnished to us by Drs. Rankine and Fairbairn, which we have embodied into our paper of October, 1863, we now give the same in the table below, and the mode of obtaining it is as follows:—

1st. For a given volume of steam the quantity of energy created varies directly as the pressure; 2d. The total heat contained in two equal volumes of steam of different pressures is proportional exactly to their respective densities; and the economic value or the absolute energy contained in steam is, therefore, represented by *the ratio* of the rates of increase of density with pressure.

With regard to the useful work obtained from steam, it may be assumed in this comparison that in non-condensing engines all steam admits of being expanded down to the pressure of the atmosphere, and that the whole of the energy contained in atmospheric steam is absorbed by the resistance of the atmosphere; upon these assumptions the quantity of work in foot-pounds contained in a pound weight of steam at any pressure is expressed by the formula (1),

$$p\,v\left(1 + \text{hyp. log.}\frac{v_1}{v}\right) - p_1\,v_1 \quad . \quad . \quad (1)$$

where p and v stand for the pressure per square foot, and the volume in cubic feet of a pound of steam of any density, and p_1 and v_1 for the pressure and volume of a pound of steam at the atmospheric pressure; the results of this formula are contained in column 5 of the table below, and the rate of increase of efficiency or the economic value of the steam is contained in column 6.

TABLE

OF ECONOMIC VALUE OF STEAM AT DIFFERENT PRESSURES.

Absolute Pressure in lbs.	Rate of Increase of Pressure.	Rate of Increase of Density.	Economic Value of Energy Created.	Non-condensing Engines.		Condensing Engines.		Rate of Economy, non-condensing Engines being taken as unit.
				Work in one Pound of Steam.	Economic Value of Steam.	Work in one pound of Steam.	Economic Value of Steam.	
15	1,000	1,000	1,000	0	$\frac{1}{8}$	48,296	0,54	8
25	1,666	1,620	1,027	29,235	0,72	78,122	0,87	2,6
30	2,000	1,917	1,042	40,392	1,00	89,450	1,00	2,2
40	2,666	2,533	1,053	57,674	1,42	106,914	1,19	1,8
50	3,333	3,090	1,078	72,634	1,79	122,424	1,36	1,6
60	4,000	3,682	1,086	84,065	2,08	133,990	1,49	1,5
70	4,666	4,274	1,091	93,922	2,32	143,901	1,60	1,5
80	5,333	4,830	1,104	103,518	2,56	153,731	1,71	1,4
90	6,000	5,402	1,110	111,140	2,75	. .	. .	. .
100	6,666	5,992	1,112	117,746	2,91	. .	. .	. .
110	7,333	6,574	1,117	124,066	3,07	. .	. .	. .
120	8,000	7,154	1,122	129,733	3,21	. .	. .	. .
130	8,666	7,660	1,130	136,226	3,37	. .	. .	. .
140	9,333	8,202	1,137	141,742	3,50	. .	. .	. .
150	10,000	8,731	1,143	147,004	3,63	. .	. .	. .
160	10,666	9,282	1,148	151,662	3,75	. .	. .	. .
165	11,000	9,553	1,151	153,902	3,81	. .	. .	. .

It may not be without interest, while engaged upon this subject, to extend this comparison to condensing engines, in the case of which it may be assumed that steam at any pressure can be expanded down to 5 lbs. below the atmosphere, and that one-half the energy contained in steam at the atmospheric pressure is absorbed by the air-pump and the condenser, though in practice it never reaches that amount; the work in foot pounds contained in a pound of steam, at any pressure, is then expressed by formula (2),

$$p\,v\left(1+\text{hyp. log.}\frac{v_2}{v}\right)-\frac{1}{2}p_1\,v_1 \quad . \quad . \quad (2)$$

where $p\,v$ and $p_1\,v_1$ retain their former meaning, and v_2 represents the volume in cubic feet of a pound of steam at 5 lbs. below the atmospheric pressure; the results of this formula are contained in column 7, and the rate of economy in column 8. For the information of those who are of opinion that the condenser has become a useless adjunct to the steam engine, and should be consigned to its grave alongside the immortal Watt, its father, we have given in column 9 the relative economy of condensing engines compared with non-condensing engines, and we shall be much surprised if these figures do not cure those who labor under the above-named delusion, should they cast their eyes upon these pages; these figures, in fact, show that at any pressure condensing engines must be more economical than non-condensing engines working at the same pressure; and from columns 7 and 5, it may be seen that steam at 55 lbs. effective pressure in condensing engines yields as high a duty as steam at 150 lbs. effective pressure in non-condensing engines; and this, no doubt, does account for the fact that the locomotive engine, though working under great disadvantages, such as high velocities of piston, contracted and difficult steam passages, cooling influence of the atmosphere, and others, works nearly as economically now as the marine engine or even the stationary engine.

It is to be regretted, however, that superficial observers, instead of tracing this latter fact to its real source, have drawn from it the conclusion that very high speeds of piston are not detrimental to the economic working of the steam engine, and are advocating high piston speeds in consequence; although all observations with the indicator show, and scientific reasoning sustains the fact, that steam working under such conditions loses a great per centage of its energy through wire drawing and friction.

We are fully aware that the quantities of work given in columns 5 and 7, are not actually realized, but the ratios given in columns 6 and 8 are not on that account considerably altered. We know also that steam is not expanded down to the limits we have assumed, but the assumption which we have worked upon only shows in a less favorable light the one fact which we have desired to impress upon the minds of our readers, viz: that the steam engine becomes economical in proportion as high pressure steam is used.

Prevention of Decay and Oxidation in Ships.

From the Journal of the Society of Arts, No. 572.

As the prevention of decay in the timbers of wooden-built ships, and the fouling and oxidation of the plates of iron ships, have received considerable attention from the Admiralty and Merchant Ship-owners, the following *resumé* of all the specifications at the Patent-Office bearing on this subject is given:—

Dipping timber in boiled oil is a very ancient practice, and it would be difficult to trace its origin. In 1739 Alexander Emerton took out the first recorded patent for preserving wood from decay. He prepared the planks or boards with boiling oil in the then old way, and afterwards coated them with compounded poisons, powdered glass, and sand, cemented with painting colors and oils, laid on as paint. The next patent, which was for preserving copper, or plates of which copper is a basis, was granted in 1790, to Collins & Wyatt. They covered the plates with lead or tin. In the earlier part of the present century several chemists recommended decoctions, in the form of vegetable poisons, for saturating timber, and thus destroying all animal life in the green wood. None of these poisonous solutions seem to have succeeded, for, had they been found efficacious, their application would have been continued. There was then an interval, during which the stoppage of decay seems to have been abandoned, and dry rot allowed to take its course. In 1822, John Oxford secured a patent, whereby he undertook to prevent oxidation or decay in iron or wood, by preparing tar in such a manner as to stop the evaporation of the oil contained therein, saturating it also with chlorine gas. This purified oil is then mixed with 100 parts of white lead—or of red oxide—25 parts of carbonate of lime, and 25 parts of purified coal tar added to the oil of tar. These ingredients are then applied as a paint. In the first days of iron in ship-building, rust was found to be a drawback to its general introduction. Scientific men saw the disadvantage, and sought to remedy the defect. Galvanic action, it was considered, would set all right, and the earliest patent in this direction was taken out by G. G. Bompass, in 1830. He sought to preserve metals from corrosion by an electric or galvanic process. For copper to be protected in sea-water he attaches an alloy of 9 to 10 parts of zinc with 100 parts of copper. In protecting iron he employed an alloy of tin consisting of from 10 to 150 parts of tin combined with one of zinc. Following in the footsteps of Mr. Bompass, in the same year, Mr. John Revere patented an invention for fixing zinc protectors to the brace or stud of chain cables, and other iron surfaces exposed to the action of salt water. These galvanic zinc protectors were riveted or soldered on according to requirement. It is known that one of the most distinguished of our electricians is in favor of inserting strips of zinc in the plates of ships; but if this principle proved correct in practice, it would long since have been universally adopted. Zinc plays an important part in patents for the prevention of oxidation. In 1837 Jacob Perkins got protection for a plan of coating copper tubes of

boilers with a preparation consisting of two-thirds of zinc with one-third of copper; but he had been preceded in 1832 by Captain H. W. Craufurd, R.N., who proposed to preserve copper and iron from oxidation by coating with zinc paint in a fused state. Over this he laid a second covering of pure tin, or tin alloyed with lead. Captain Craufurd explains in detail his method of compounding the ingredients. In 1838, Le Comte de Fontainemoreau, considering Captain Craufurd's mode of fixing or adapting the zinc to this purpose as erroneous, applied for a patent of a more comprehensive description, for applying the zinc coating to metals. Again, in 1839, Mr. Thomas Dowling patented what he terms a conservative bath, applied to metals after grinding. He describes the machinery by which he effects this, the chief of which is a zinc wheel and galvanic vapor furnace.

In 1840, Mr. J. R. Neilson came forward with his invention for the application of a coating of copper, or copper alloyed with zinc or tin, or both, to the surface of iron. This was done by covering the mould to be cast with the material. In malleable iron, dried borax or flux is spread over the iron, which is then prepared with alloy heated to a temperature sufficient to melt copper, and, in its heated state, plunged into cold water to detach the scale of oxide. Mr. Arthur Wall, likewise in 1840, mixed 20 pounds of the strongest muriatic acid diluted with three gallons of water, then added 12 lbs. of steel or wrought iron filings. The filings were heated to redness before mixture. The whole was then subjected to heating in a pan, &c., and the composition was then applied to prevent corrosion. In 1841, Mr. W. E. Newton employed silicates of potash, or soda, for making a plaster or coating to prevent iron from becoming rusty. After him came Professor R. Mallet, Engineer, of Dublin, whose varied processes are of the most complex character. Finding that iron covered with zinc, when immersed in sea-water, and certain fresh waters, gathered to itself a coating of carbonate of lime, destructive to the protective power of the zinc, and affording a surface for the attachment and growth of marine animals of the molluscous and testaceous classes, and aquatic plants, he applied chemical means to detach the scales of oxide from iron, and then plunged it into a preparing bath. After undergoing a series of processes, the metal is coated with an alloy or zoofagous paint, which paint is rendered poisonous by admixture of salts of metals, by means of which he sought to render the zinc effective as an anti-corrosive protector. In 1841, also, Mr. E. Morewood endeavored to preserve iron from oxidation or rust by tinning it, and then dipping the tin covering or surface in molten zinc. Moses Poole, in 1845, claimed to possess an invention whereby he rendered iron more hard and durable, and free from oxidation, by the use of ferrocyanide of sodium, calcium, barium or any other alkali, or alkaline earthy base; to be used in a manner fully set forth in his specification. In 1846, Mr. Andrew Smith improved upon the plans for melting the zinc. He employed a bath of lead or tin, or any composition or medium that melts at a lower degree of heat than zinc, by which means the heat from the fire of the furnace s taken up and transmitted to the receptacle containing the zinc for

melting. Baron Wetterstedt, in 1846, added the regulus of antimony to lead sheets, combined copper with antimony, made sheet metal by using lead and tin, and lastly, protected metals by paints thus prepared:—1st. One part of regulus of antimony to three parts of copper, mixed, melted together, run out into water, and then heated gently. Two parts of oxide of copper are added, and moistened with naphtha. The whole is then added to a composition of tar and naphtha. 2d. Another paint is compounded of 30 lbs. of tar, 30 lbs. of pitch, 20 lbs. of dried soot, 4 lbs. of tallow from sperm oil, and naphtha added for consistency.

Mr. C. H. Paris, in 1849, coated metals with glass or vitreous matter. The metal went through a cleansing process. Gum water is then applied, and over this the dry or powdered glass is shaken, and then fused by heat till a glass surface is formed. Mr. Paris claimed the application of carbonate of soda for applying glass in this manner. Mr. J. MacIntosh, in 1852, made a paint from decomposed india-rubber in combination with oils or fatty matter, saponified by metallic salts, with lime for thickening the liquid. For bottoms of ships he recommends the india-rubber, when in a fluid state, to be combined with metallic soap, thickened with lime and colored by pigments. Messrs. Hughes and Firmin, in 1852, manufactured lamp black from the vapor of coal tar, dead oil, dead oil salts, coal pitch, naphtha, linseed oil, and other materials. From the products a fuel is produced, and this residue has by another inventor been mixed with oils, ground and made into a paint. In 1852, also, Mr. R. M. Glover took out a patent for a preparation of arsenite of lead and arsenite of copper, and the red and yellow sulphurets of arsenic. The proportion of each were as follows:—Two parts, by weight, of arsenite of lead, one of realgar, one of orpiment, and one of arsenite of copper. In the same year, Mr. J. Murdock invented a variety of driers for zinc when the white of zinc is employed instead of white lead. The protoxides are manganese, cobalt, iron, tin, and nickel; for acids, the benzoic, urobenzoic, and the boric. In 1852, Mr. Binks, patented a substitute for linseed or drying oils, in the products derived from dissolving what are called insoluble soaps. A pigment is then ground in this solution, and the paint is ready for application. The pigment may be white lead, oxide of zinc, lamp black, or any other. J. C. Medeiros, in 1853, proposed the use of mercury or quicksilver on iron plates for sheathing ships. The salts of mercury are dissolved, then a bath is formed and the plates allowed to remain in the solution till their surface is equally and regularly amalgamated.

Mr. Newton, in 1854, made a paint from ground plumbago, pulverized charcoal, and the black soot formed by the burning of bituminous matter, along with ivory black, or bone or lampblack. Mr. Ryder also, in 1854, described a method for mixing gutta-percha with common resin, or tar, pitch, or asphaltum, dissolving them in impure benzole or coal naphtha. Mr. Newton took out a second patent, in 1854, for the production of a siccative black, brown, or grey pigment or coloring matter, by the admixture with the gas tar, or other organic substance to be carbonized for the purpose, of the oxides of potassium,

sodium, calcium, aluminium or other alkaline or earthy bases for paints. Mr. F. Ransome, in 1854, patented a mixture, consisting of ground oxides and carbonates of lead or zinc, and carbonate or sulphate of barytes with soluble silica. Mr. J. Rogers, in 1855, to prevent oxidation, deoxidizes metallic ores by a revolving cylinder, fitted with helical or screw-formed divisions to receive the ores in a pulverized state, and then submits the same to heat, and constant agitation by the revolution of the cylinder. Mr. B. Rosenburg, in 1855, manufactured a paint as follows:—100 lbs. of triturated white lead, 2¼ gallons of copal varnish, 1⅛ gallons of spirits of turpentine, 1⅛ gallons of linseed oil, and, for coloring, a small quantity of red lead. Before the metal is painted it is subjected to the fire for cleansing, and when cool the preparation is applied, then varnished with copal, and dried by a hot air process. Mr. J. E. Cook, in 1855, proposed a composition consisting of gum shellac, dissolved in methylated spirit or in wood spirit. In 1856, the patent of Messrs. Bancroft & White claims the manufacture of oils from petroleum, for preserving metals and ships' sheathing. Mr. A. F. Mennons, in 1856, obtained a patent for a non-conducting and inoxidable composition for metals, made thus:—

Argillaceous clays, containing a certain proportion of alumina,	100 parts.
Oily substances and residues,	6 "
Oil sediment,	5 "
Fat,	2 "
Animal charcoal,	2 "
Mucilaginous substances, such as glue, &c.,	2 "
Wood sawdust, already employed in the purification of oils in the process of dyeing,	10 "
Waste hair well beaten,	4 "

To the preceding materials a decoction of logwood and soot is then added.

Mr. J. M'Innes, in 1856, was granted a patent for coating metals with powdered emery stone mixed with a varnish of shellac dissolved in spirits of wine, with the addition of castor oil. As emery contains 87 per cent. of aluminium, Mr. M'Innes considered that this paint would be solid enough to resist all action in the water, and never decompose. Mr. R. D. Atkinson, of Hull, in 1856, invented a plan for coating and protecting metals from oxidation, by depositing copper or brass upon surfaces of prepared iron, the deposit to be melted in conjunction with carbonic acid gas, the coating to be put on by a brush, or through the medium of galvanism. Depositing brass on iron is now being successfully carried out at Portsmouth, by Mr. Wielan, on armor plates and other iron surfaces. Mr. A. Reid, Mineralogist, in 1856, describes in his specification what he deems a sure way of preventing oxidation. He places the iron in a properly constructed furnace, then covers the metal with soot, or other matters possessing the like element, the temperature is then raised to red or white heat, and continued for half an hour, or according to the size of the iron operated upon. It is then suffered to cool, the surface is cleaned, and Mr. Reid asserts that a coat impervious to rust is formed. If this is verified by positive experiments, the cheapness and simplicity of the plan deserves to be widely

known. Mr. Joseph Poleux, of New York, communicates, in the same year, a plan to overcome oxidation. He employs muriatic acid, nitric, or sulphine acid, of the ordinary degrees of concentration in commerce, without dilution combined with the introduction of spelter into the cleansing process. In 1857, Mr. G. Bedson patented a new process. He melts a quantity of pitch derived from mineral tar, and a proportion of tar oil, with caoutchouc tempered with tar oil and shellac, the substance to be solid and elastic when cold. Mr. C. F. L. Oudry claims depositing copper on a preservative or intermediate coating instead of on the metal. He deposits copper in a pure state to any thickness on all metals. Mr. C. Iles, in 1857, describes a means of applying earthy cements to metals. In 1858, Mr. J. Coutts received a patent for applying the following pigment by heated air:—

Carbonate of baryta,	·650
Litharge,	·065
Arsenious acid,	·030
Asphaltum,	·050
Oxide of calcium,	·030
Creosote (oil of tar),	·175

Perhaps the most novel introduction is that patented here by Messrs. Bouchard & Clavel, the Paris bankers, in 1858. On the estate of La Gruerié, in Charney, Department of Yonne, France, is found an earth of the ochre description, called "Burgundy Red." This earth contains most valuable properties, and is said to be an exceedingly good preservative against rust. It is used as a cement and paint by admixture with the following:—

Burgundy red,	66 parts,
Grease of oil,	15 "
Lime,	11 "
Unburnt earthenware, chalk, or Roman cement,	8 "
	100 "

This is said to prevent oxidation if the earth is mearly diluted with volatile oil. D. M'Crae, in 1858, was allowed a patent for preserving bottoms of ships from fouling or decay. He applies grease from the cells of boiled bones, kitchen-stuff, and butter without salt; a poisonous matter is mixed with these fatty substances. Mr. G. P. Lock, in 1858, made a composition for the under coating of iron ships, made from iron ore ground in boiled linseed oil 50 per cent., oil of turpentine 50 per cent., well mixed. For the outer coatings, white lead 40 per cent., blue mineral or copperas 10 per cent., and oil of turpentine 50 per cent. In 1859, Mr. Henry, on the part of Moisant & Co., sought protection for bituminous products and compounds of bitumen for preventing oxidation. Mr. T. J. Laballe made a preparation of caoutchouc paints and colors for vulcanizing. Mr. J. Crawford, of Liverpool, in 1859, applied for a patent for a metallic paint or varnish, composed of plumbago, or black lead, fine or gum varnish, arsenic, and spirits of turpentine mixed. Mr. F. W. Emerson, in 1859, prepared an anti-corrosive paint from oxi-chloride of lead, mixed and ground with oil, turpentine, varnish, or other vehicle. Mr. Weild, in 1859, sought to economize time and labor,

by a mechanical machine for applying paints to metals on large surfaces. Mr. James Meikle, in 1859, proposed coating iron ships with asphalte. In the same year M. Auguste Pin dissolved sugar in muriate of zinc, then added wax and soap, in which was incorporated calcareous stones, phosphate of soda, sulphate of zinc, and copper, and the syrup of potatoes or sugar, with powdered marble, quartz, or felspar.

In 1859, Mr. F. G. Spilsbury, of Louvain, applied for a patent for the manufacture of a paint. He took sulphate of lead, and heated it to a red heat, either by itself or mixed with alumina or other earths; the pigment thus obtained to be washed first with sulphuric acid, then with water, when it is finally dried. Previous to drying the pigments are digested with salts of tungstic acid, molybdic acid, titanic acid, tantalic acid, arsenic acid, acid of antimony, or other metallic acid, or with mixture of the above salts. A combination between the sulphate of lead and the metallic acid or acids is obtained, and the resulting pigments are dried in like manner after having been cleared from all adhering salts. The pigments may then be mixed with oil and used as a substitute for white lead. Mr. J. F. J. Lecocq, in 1860, prepared a calcareous varnish for coating iron and the bottoms of ships. Mr. H. Kemp, in 1860, patented a composition consisting of peat tar, wood tar, methylated spirit, peat oil, or linseed oil, arsenic resin and carburet of iron, for preserving ships bottoms. Mr. Allen's plan for making a coating or anti-corrosive paint for metals is thus given:—Ammoniacal liquid obtained from coal tar, or gas tar, prevents incrustation in boilers, and is applicable to painting the inside plates. Messrs. Pile and Smyth, of West Hartlepool, took out a patent in 1860. They employ a red composition and enamel, consisting of a combination of litharge, Venetian red, and pine varnish. Over this composition is applied a coating of resin, gums, or any pitch or bituminous substance with the addition of coal tar or oil. This is put on in a hot lava state, and the process is called enameling. An impermeable oil varnish was patented by M. Antoine Bonet, in 1860, composed of 100 parts of alcohol, 100 parts of spirits of turpentine, one part of sulphuric ether, and one of carbonate of soda.

Mr. Robert Smith, ship-owner, of Finsbury, applied to the Patent-Office, in 1860, to protect his system for keeping vessels from fouling and worming. He applies equal parts of pitch, tar, resin, and turpentine, with any other adhesive compound. Assafœtida to be mixed with the foregoing, as a poison to destroy life. When the coating is laid on, and dry, the whole to be covered with paper or cloth. Mr. G. Hallet, in 1860, in his patent explains his method of protecting metal. He grinds the oxide of antimony to powder, then dries it, and mixes with it 12 lbs. of linseed oil to the hundred-weight of powdered oxide. Mr. Richardson, 1861, to prevent oxidation, would cover the metal with vulcanized india-rubber, cloth, or gutta-percha, the object sought being to provide for unequal expansion of the metal and coating. Mr. Francis Pulz, Chemist, 1861, causes oxygen to be passed through sulphuric acid, to render the oxygen more active as an oxidizing agent, as it combines, when so treated, with other substances for which it has

an affinity, for manufacturing purposes. Mr. Pulz, also, in a second patent, submits oily matters to this oxidizing agency, by causing the sulphureted gas to pass through them when in a liquid state. Mr. Martin Miller sends a communication, in 1861, for coating metals by metals or alloys in different ways. Mr. John Hay, in 1861, patented a drying oil. He lays a non-conducting coat, and then makes a paint by grinding in linseed oil the black or protoxide of copper, which is then boiled till reduced to the sub-oxide, and by thus oxygenating the oil he claims to have formed a quick drying cupreous oil. Mr. John Snider, of the United States, patented here a compound, in 1861, for coating metals. He reduces amorphous graphite to fine powder, and then mixes it with ore by the agency of a heated steam-pipe. When cool and dry, one pound of oil is added to three pounds of the powder, and when the ingredients are combined, hot pure bees-wax, in the proportion of one pound of wax to 10 lbs. of graphite, is mixed. Afterwards linseed oil may be added. Mr. Snider details his manner of manipulating and preparing the graphite and ore. Messrs. Hallett and Stenhouse, in 1861, obtained a patent for the manufacture of pigments for coating surfaces. They employ native oxide of antimony, chemically treated in ways too intricate for explanation in this abbreviated outline, and mixed with red lead or litharge. They sometimes take type metal or worn-out types, reduce them to a coarse powder, and then mix them with their own weight of zinc, and calcine them. This produces a yellow pigment.

New Engraving Processes,—Sunk and in Relief.

From the London Builder, No. 1103.

Some curious experiments, executed before the Emperor and Empress of the French, by M. Dulos, are thus described in *Galignani's Messenger*:—A sheet of copper, drawn on with lithographic ink, is subjected to the voltaic pile, by which it receives a deposit of iron on those parts not covered by the ink. The ink is then removed by means of benzine, and the sheet is then in the state of an engraved copper-plate—that is, the design is sunk into the plate, and the deposit of iron constitutes the lights. The plate is now dipped into a bath of cyanide of silver: under the action of the galvanic current, silver is deposited on the copper, and not on the iron. The plate is then taken out, and mercury poured upon it. Now, since mercury exercises no action on iron, it can only attack the silver which has filled up the lines originally made with lithographic ink. Hence, where those lines are, we now see mercury standing up in relief. Plaster of Paris is now poured over the plate in this condition, and thereby an impression is obtained in which the reliefs made by the mercury are re-produced hollow. [Why the ink was removed, or silver deposited in this case, is not clearly stated.] By the aid of the pile copper may be deposited on this impression, and the hollows will then come out again in relief. One thus obtains not only a plate which may be printed from, but a matrix which will give an indefinite number of plates. For typographic en-

graving, the sheet of copper, after being drawn upon, receives a coating of silver, which only goes upon the metal, leaving the lithographic ink untouched. The ink is removed, as before, by benzine. The surfaces which are thus laid bare are oxidized, and mercury is again poured on the plate. This metal recoils from the oxidized lines, and collects on the silver, making reliefs where the lights ought to be. An impression in plaster is obtained as before, and the electro-chemical plate which is to be used for the printing has the lines of the drawing in relief as required.

For the Journal of the Franklin Institute.

Improvements in the Barometer and Thermometer. By JOHN THOMSON, of Wayne, Du Page County, Illinois.

The Committee on Publications will please insert in the "Journal of the Franklin Institute," this notice of a series of improvements on the Barometer, including also the Thermometer, which I shall detail as briefly and explicitly as possible.

First in order is what the inventor designates as the Farmer's barometer. It consists of the stem of a common *Thermometer* tube. Into this tube is introduced a single drop of mercury and then both ends of the tube are covered with a piece of silk. A metallic bulb is then cemented to one end of the tube, while the other is left exposed to the action of the atmosphere. A small steel ring is placed upon the stem to slide up or down; and the instrument is complete.

The object of the inventor in producing this instrument, was wholly to befriend the farming community, and such others as are more or less dependent on the condition of the weather, for their operations, by giving them a cheap barometer, as reliable to the most expensive instruments that are made.

It will be observed that the small globule of mercury within the tube is the index, whose position is to be noted, forming as it does a movable partition, dividing the air in the tube into an upper and lower portion. As changes in the weather are indicated not by the actual weight of the atmospheric column, but by changes in that weight, so this instrument is designed especially to indicate those changes, giving notice of the coming storm, or the approach of more favorable weather. No scale of inches is upon this instrument, as it is designated only to indicate *changes*.

The standard place for the index is about midway of the tube, when the temperature is 50° and the atmospheric pressure 30 inches.

To make an observation with this instrument, place it in a tumbler of newly drawn water from the well or spring, which may be supposed to be of the same temperature from time to time. The air in the bulb is thus brought to the same temperature as the water. Now upon the upper side of the index we have the free atmospheric pressure while upon the lower side presses the elastic force of the combined air; and

the index itself, moving freely in the tube, will always occupy the position where these two forces are balanced. The ring upon the tube is then slipped to where the index rests.

The next, and each successive observation, is to be made in precisely the same way, *i.e.* by placing the bulb in newly drawn water from the same well or spring,—and as the index is above or below the ring a diminution or increase in the weight of the atmosphere is indicated; showing the approach of storm or the reverse, just as in all other barometers.

In summer or in heated positions when the instrument is not in use the index may ascend to the top of the tube, and rest against the silk covering; and during winter or in cold positions it will rest upon the lower covering. The object of these coverings is to prevent the escape of the mercury, while at the same time giving a free passage to the air of the atmosphere.

This barometer it will be seen is quite portable, and very cheap.

The *second* of these improvements is quite ingenious and philosophical, being both barometer and thermometer combined in the same instrument. Its construction and operation are precisely similar to the "Farmer's Barometer," except that the tube is longer, say 12 to 18 inches, and that it has a scale attached to it. This scale is graduated for temperature on one side of the instrument, from top to bottom; and on the other side are marked the inches and their parts, for the barometer.

As a *barometer* this instrument acts precisely as the former, already described, and therefore needs no further explanation, the only requisite as with the other, being to bring it to one and the same temperature at each observation.

And now to illustrate its action as a *thermometer*, let us suppose that the uniformity of temperature is obtained not by spring water, but by placing the bulb in the mouth, thus giving it the temperature of the human body 98°.—Now it will be understood that the temperature of the air will be told approximately at all times by the index, when the bulb is not in the mouth. The index, however, is being acted upon by the atmosphere from without, and consequently this approximate temperature must be corrected by adding or subtracting according as the index is above or below the standard temperature, (98° in the case supposed) when an observation is made. Suppose, for instance, that the index is at 50° when the instrument is in the air, and rises to 98° when the observation is made, then the temperature of the air is just 50°; but if the instrument had gone 10° higher, that 10° is owing to a lightness of the atmosphere and must be added to the 50° to give the true temperature, viz., 60°; but on the other hand if the index falls 10° short of the standard, it is owing to an increase in the pressure of the atmosphere to just that extent, and consequently the 10° must be subtracted and the true temperature is 40°.

The standard of this instrument is 98° and 30 inches.

If this instrument be properly made, and a true uniformity of heat applied, no thermometer can be more accurate.

The third and last improvement, I have the pleasure of communicating is the lengthening of the scale of the common mercurial barometer to an indefinite extent. Thus the *tube* of the common parlor barometer, instead of the wheel and its counterweight in the cistern, is furnished with a thermometer tube three feet long, open at top and bottom, and standing side by side with it, wherein the rise and fall of the mercury will be seen on a very largely increased scale. This additional tube has its lower end widened to, say, twelve times the size of its bore, and is partly filled with colored alcohol. This is set into the mercury in the open cistern. The specific gravity of the alcohol is so much less than that of the mercury, that a sufficient column of alcohol will be easily sustained in this additional tube, to be acted on by the atmospheric pressure. The lower end being enlarged in the ratio of twelve to one, it follows that a rise or fall of one inch of the mercury in the cistern will necessitate a rise or fall of twelve inches in the alcohol in the tube. Consequently a range of three inches of the mercury would be indicated by a range of three feet of the alcohol.

To prevent the evaporation of the alcohol in this constant rise and fall, the inventor places one of his small drops of mercury over the alcohol with about an inch of air between. This drop of mercury rises and falls with the alcohol. The top of this tube is covered with a piece of silk to prevent the entrance of dust, &c.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, June 16, 1864.

William Sellers, President, in the chair.
Fairman Rogers, Vice President, } present.
John F. Frazer, Treasurer, }
Washington Jones, Recording Secretary.

The minutes of the last meeting were read and approved.

Donations to the Library were received from the Institute of Actuaries, and the Society of Arts, London; la Société d'Encouragement pour l'Indrustrie Nationale, Paris, France; Hon. William D. Kelley, U. S. Congress, Washington, D. C., M. W. Baldwin & Co., and Prof. John F. Frazer, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's report for May was read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (5) were proposed, and the candidates proposed at the last meeting (13) were duly elected.

The By-Laws of the Institute as reported by the Committee and amended at the adjourned meeting held on the 9th instant, were again taken up for consideration, when they were further amended, and finally adopted.

Mr. P. E. Chase illustrated by a diagram the combined action of rotation and lunar attraction, which led him to believe that there should be four atmospheric spring tides, and four neap tides, in each lunar month, and stated that his theory was confirmed by the barometric observations at St. Helena, and in other places. He thought it would also be found that the same influences produce secondary spring and neap tides in the ocean, as well as in the air.

BIBLIOGRPHICAL NOTICES.

Practical Treatise on Limes, Hydraulic Cements, and Mortars. By Q. A. GILMORE, A. M., New York: Van Nostrand, 1863. 8vo. pp. 333.

This is one of the series of papers on Practical Engineering, issuing from the United States Engineer Department, and had we noticed the work when it was first published, perhaps it might have been necessary to say who the author was. Since then, however, he has so distinguished himself in his profession, that any notice of him is unnecessary. This work contains a record of certain experiments and researches made under the authority of the Engineer Bureau of the War Department from 1858 to 1861, upon the various hydraulic cements of the United States, and the materials for their manufacture. The experiments were carefully made and are well reported and compiled. It is strange that, in a matter so interesting to engineers, and apparently presenting no very great difficulties, except such as patience and science could overcome, so little should be known; but it seems certain that our knowledge of what is necessary to constitute a good hydraulic cement is yet almost at a minimum. What is known, and the means of knowing more, will be found in this work, which is presented with the usual excellence of execution of the publisher.

Elements of Chemistry. Theoretical and Practical. By WILLIAM ALLEN MILLER, M.D., LL.D. *Chemical Physics.* Part II. *Electricity and Magnetism.* From the 3d London Edition. New York: John Wiley. 8vo. pp. 191.

We do not pretend to know what Chemical Physics are or ought to be. All physical knowledge is important to chemists, and chemistry is a branch of physics; but however this may be, and whatever may have been the intention of the work, it is a very excellent practical treatise on electricity and magnetism, full and accurate and lucid in its expositions, and well illustrated by tables and wood-cuts.

Ewbank's Hydraulics.

The 15th edition of this interesting work is about to be issued by the publishers in New York. No further commendation of the book is necessary than this simple announcement that it has so rapidly reached a 15th edition, and that without receiving or requiring any of the artificial means of distribution so frequently used.